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MARCH 1837.

Practical and Theoretical Mechanics.

Report on Strength of Materials for Steam Boilers —CONTINUED.

Hence it appears that by a mean of 34 out of seventy-five experiments in nine different vessels, with five different liquid capacities, and composed of three different kinds of materials, we obtain a result not sensibly varying from .1134, as the specific heat of the iron standard piece between ordinary temperatures and 212° Fahrenheit.

The next step in this investigation again required the use of the copper cylinders, but instead of the *heating apparatus* W being filled with water, it was made to contain mercury, which allowed a higher temperature to be given to the vessel M. This latter vessel was now filled with melted tin, instead of mercury, as well to avoid the inconvenience from mercurial fumes, as to obtain the specific heat of iron at a second fixed temperature, the melting point of tin. It needs scarcely be mentioned, that the same degree of exactness in the accordance of experiments at temperatures above 400°, as at 212°, is hardly to be expected. Table XI. exhibits a number of trials made in the manner just pointed out.* A certain amount of error may possibly have been introduced into these experiments by the want of uniformity throughout the mass of melted tin; for, after withdrawing the standard piece and lowering the thermometer to the bottom of M, it was found that a difference of a few degrees, was a possible occurrence; but as the bulb of the mercurial thermometer, which marked the temperature of the melted tin, was generally kept at the same level with the centre of the standard piece, any difference between the two, must be trifling in amount.

* It will be evident on a comparison of this table with those which have preceded, that the general law observed by Petit and Dulong [*Ann. de Chim. et de Phys.* Vol. VII.] of an increase of specific heat by increase of temperature, when the method of heating water is employed, is confirmed by these results; but experiments on the production of vapour hereafter given, exhibit a very striking conformity, in regard to specific heat, with those made below 212°.

TABLE XI.

Experiments to determine the specific heat of the standard piece of the steam pyrometer at temperatures above 212°—containers, two copper cylinders, weight of standard piece 6000 grains. Heating performed in bath of mercury or melted tin.

No. of the experiments.	Temp. of air outside of tin cylind. at beginning.	Temperature of air *outside* at end.	Temp. *inside* of cylinder at beginning.	Temperature of air *inside* at the end.	Temperature of water at the beginning.	Temperature of water at the end.	Temperature of iron at immersion.	Temperature lost by the iron.	Temperature gained by the water.	Weight of water in the container.	Weight of copper in the container.	Equivalent of container in weight of water.	Equivalent of thermometer in water.	Total matter heated.	Specific heat.	REMARKS.
	°	°	°	°	°	°	°	°	°	grs.	grs.	grs.	grs.	grs.		
1	71.5	71.	67.6	67.4	61.4	67.45	400	332.55	6.05	38659	19718	2050	196.7	40905.7	.12403	The equivalent of the container is found by multiplying its weight by the specific heat of copper already ascertained. Ending at the temperature of the internal air; this result must be too high.
2	70.	71.	66.8	68.1	63.45	73.40	610	536.6	9.95	38659	19718	2050	196.7	40905.7	.12641	Began 3.35° below, and ended 6.6° above the air inside the shield. Air gained 1.3°.
3	71.	71.	67.7	67.7	58.75	68.3	560	491.7	9.55	38659	19718	2050	196.7	40905.7	.13241	Water at beginning 8.95° below air in shield; at the end, .6° above it.
4	80.	80.	75.	78.	71.8	78.55	442	363.45	6.75	38659	19718	2050	100.	40809.	.12631	Water at beginning 3.2° below internal air, at the end 3.55° above it; air *inside* gained .1° during the operation—*outside* air above temperature of water for the whole time, result must be too high.
5	80.	80.	75.1	75.25	67.9	74.75	442	367.25	6.85	38659	5168	531	100.	39290.	.12214	Water at beginning 7.2° below air inside, and .5° at end, leading to too high a result.
6	80.5	85.5	79.5	81.	71.9	78.7	446	367.3	6.80	38659	5168	531	43.7	39233.7	.12110	Water at beginning 7.6° below the internal air, and .8° at the end, result as before—inside air gained 1.5°.
7	85.	86.	80.	81.5	76.	83.26	450	366.74	7.26	38659	5168	531	43.7	39233.7	.12944	Began .4° below internal air—ended 3.26° above it, air inside gained 1.5° during the experiment.

The last arrangement for demonstrating the specific heat of iron, was in the nature of a verification of the methods already detailed, by means of a direct application of the standard piece to the purpose for which it is ordinarily employed—that of generating vapour instead of heating water.

It was, for this purpose, heated as before described, in the bath of melted tin to such temperatures, above 212°, as were deemed necessary, and immediately plunged into boiling water. The *effect* produced, was now ascertained by multiplying together the weight of vapour generated, and the latent heat of steam; while the *cause* was found in the weight of iron, its specific heat and the temperature which it expended. The shield to defend the iron in transitu was employed, and the other precautions to avoid error were still persevered in. The results will be found in table XIII.

Before proceeding however with the detail of those trials, it is necessary to state the mode of ascertaining the latent heat of the vapour of water, which enters as an essential element into the calculations of that table. It will be perceived that the principle of the method is similar to that of Count Rumford.

Apparatus for the latent heat of vapour.

The apparatus by which the latent heat of vapour was examined, is represented in plate 8, in which A is a cylindrical vessel to contain water; B a larger cylinder formed of pasteboard, higher than the preceding, surrounding and defending it from the air; C is a stand of charcoal on which the vessel rests; D is a vessel of tinned iron 14 inches high by 9 in diameter, to prevent the vessel F (the same which has already been described as the boiler of the steam pyrometer,) from affecting by radiation the temperature of A. P is a sheet of tinned iron, attached in a vertical position to the edge of the table T, serving still further to defend A from the influence of radiation from the boiler or steam pipe. S is a cylindrical piece of cast iron, having round its lower base a ridge *r*, adapted to retain a hold of the small hook *h*, within the copper case L, intended to receive it when hot. From the upper conical part of this case rises a pipe *g*, $\frac{1}{4}$ of an inch in diameter, curved into a semi-circle at the top to dip under water. Within the curved part is a stop-cock K, adapted to regulate, or entirely to prevent when required, the flow of steam from L. At *q* is an enlargement of the pipe *g*, with a funnel-shaped tube to receive the bulb of a thermometer *e*, sustained and made tight by packing around the lower part of its stem. The purpose of this thermometer is to mark the temperature of the effluent steam. *w* is a handle formed by a number of folds of flannel made fast to the pipe. *x* is a thick roll of cloth surrounding *g* and preventing the escape of vapour exterior to the tube. The thermometer *o* marked the temperature of the apartment in the immediate vicinity of the apparatus. *i* gave that within the pasteboard case, while *t* gave the temperature of the water in A.

No fire was kept in the apartment where the experiments were performed. The container A, when quite dry, was first accurately counterpoised in a scale pan, and then taken out and weights substituted to avoid any possible error in the scale beam. The vessel being next returned to the scale pan instead of the weights, was filled so nearly with water, that the vapour to be condensed, would make it quite full; after which a counterpoise was once more effected, and the vessel being taken to its place within B, the weighing by substitution was repeated, giving the sum of the weights of the water and of its container. The counterpoise being once adjusted for a series of experiments, it was only necessary in repeating the trials with new portions of water to replace the vessel A in the scale pans, and

pour in a fresh charge of water till the equilibrium was obtained. The several thermometers were next adjusted in place, that which was to indicate the temperature of the water being made with special reference to these trials, and the weight of mercury which it contained, as well as that of the glass immersed in the water exactly ascertained.

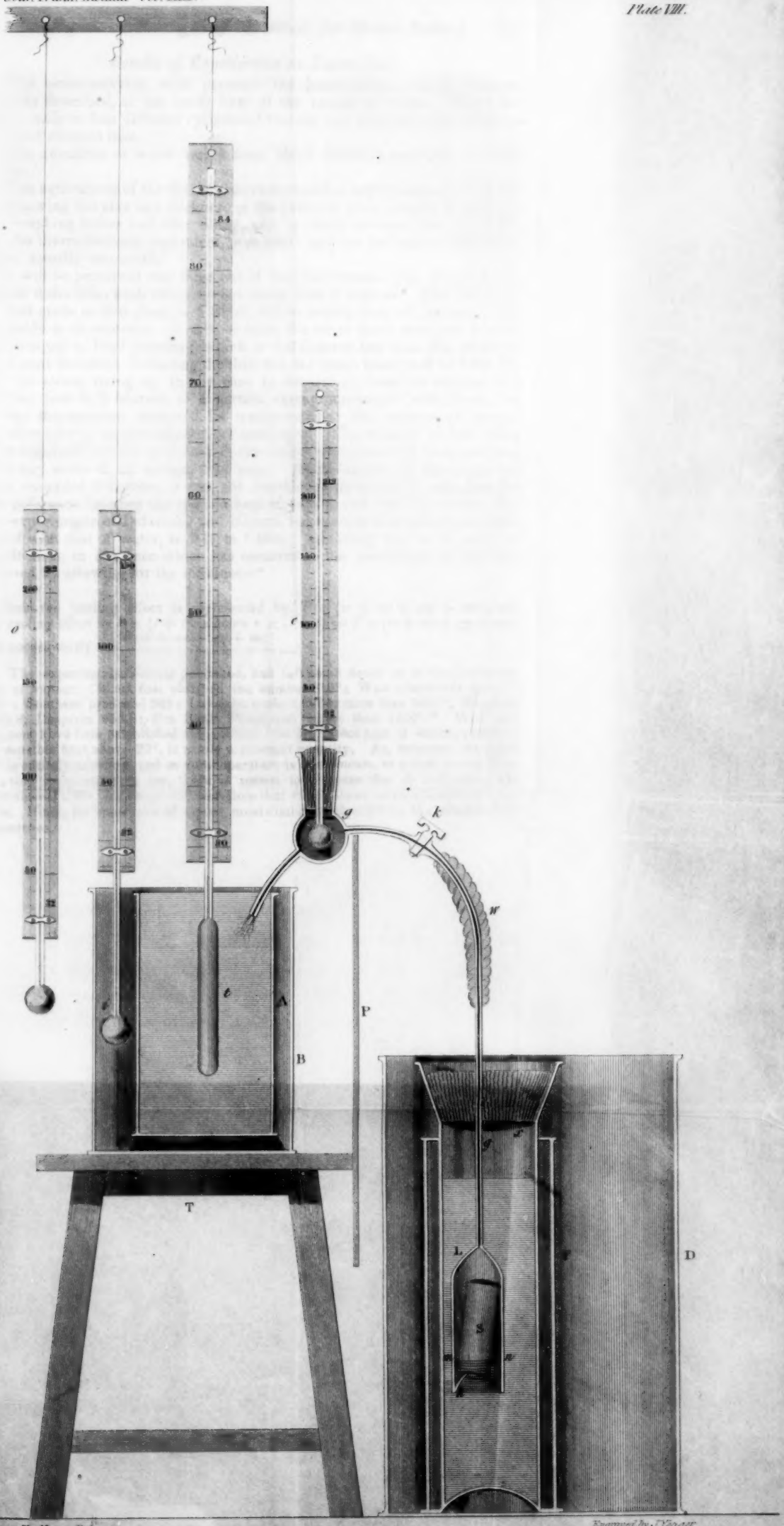
While the operations of weighing and arranging, as just described, were performed by one assistant, another having heated to a low red heat the cylinder S, inserted it in the copper case L, where being retained by the hook h, it was plunged into the boiling water contained in F, and the latter placed within D; the packing x was adjusted, and stop-cock K opened, to allow the air to be driven from the pipe g, and the whole apparatus, including the thermometer e, to be raised to the temperature of 212°. This being done, the apparatus was conveyed to the room where the water vessel was placed, and after turning the stop-cock for an instant, to expel any water which might have been condensed during the transit, the mouth of the pipe was brought briskly round and immediately plunged under the water. Here it was continued until the vessel A was perceived to be full, when it was withdrawn and the stop-cock closed, but not until the mouth was quite above the water. During this manipulation the thermometer t was kept constantly moving, to equalize the temperature of the water. This being done, the increase of weight was ascertained by again counterpoising the vessel and its contents. It is apparent that heat imparted to the water, by the condensed vapour, must be employed for heating at least three different bodies, the water, the container and the thermometer t.

It was therefore necessary to know the weight and specific heat of each, in order to determine the relation of the heating power of a given weight of steam, compared with the cooling power of a quantity of water equivalent to the sum of these three bodies. As the quantity of air which was included in the box B was small in amount, as the specific heat of air is, weight for weight, but about one fourth that of water, and as the experiments were generally performed in such a manner as to allow the air to operate partly in favour, and partly against the heating power of the steam, it was not deemed important to take into the calculation the minute quantity due to the cooling power of this mass of air. In a few instances however, its effects are noted in the column of remarks.

The results of experiments on this subject are found in table XII.

As the trials on specific heats below 212° had preceded those now under consideration, it was found convenient, to employ as containers some of the same cylindrical vessels which had been used in that investigation. The materials of each are specified in the table. The calculations are very simple when we have obtained an expression for the equivalent quantity of water equal to the three terms above specified.*

* The latent heat of steam was calculated by the following formula.
Putting w = the weight of water in the vessel.
n = that of the vessel itself.
g = that of the glass in the immersed part of the thermometer.
m = that of the liquid in the same.
x = the specific heat of container.
y = do. of glass.
z = do. of the thermometric liquid.
v = the weight of vapour condensed.
T = the temperature gained by the water.
t = the distance of the final temperature of the water below that at which the steam enters it,
and l = the latent heat of vapour at the boiling point.



Wm. Mason Del.

Engraved by J. Yeager.

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y = do. of glass.
z = do. of the thermometric liquid.
v = the weight of vapour condensed.
T = the temperature gained by the water.
t = the distance of the final temperature of the water below that at which the steam enters it,
and l = the latent heat of vapour at the boiling point.

Results of Experiments on Latent Heat.

The accompanying table presents the determination, in the manner already described, of the latent heat of the vapour of water. The trials were made in four different cylindrical vessels, one of copper, two of glass, and one of sheet iron.

The quantities of water varied from about 13000 to upwards of 39000 grains.

The equivalents of the thermometers were either approximately estimated by knowing the size and thickness of the bulbs, or were actually determined by weighing before and after filling, and in every instance the calculation for the thermometrical equivalent, was made only on the part of the instrument actually immersed.

It will be perceived that three out of the four vessels, give mean results which differ from each other by not more than 3 degrees. The third set, or that made in thin glass, and which differs widely from all the rest, ought probably to be rejected. If this be done, the other three sets give a mean result equal to 1037 degrees; which is 3.8 degrees less than that obtained by Count Rumford. Including the third set, the mean result will be 1026.83. As the steam rising up in the case L, necessarily came in contact with the hot iron S, it became, to a certain extent, surcharged with heat; but as the thermometer indicated its temperature at the moment of escape, an allowance is easily made for the surcharge. The rapidity of flow being duly regulated by the stop-cock *k*, the steam was prevented from carrying over any water in an unvaporized state. As the amount of surcharge seldom exceeded 3 degrees, it was not considered necessary to calculate for the difference between the specific heat of vapour and that of water. By the experiments of Delaroche and Bérard, the specific heat of vapour, compared with that of water, is .847 to 1.000. Admitting this to be true, the result must, in any case which has occurred to the committee, be but little affected by allowing for the difference.*

Then the heating effect is represented by $T \times (w + nx + gy + mz)$, and the cooling effect by $v \times (l + t)$; whence $v \times (l + t) = T \times (w + nx + gy + mz)$ and consequently $l = \frac{T(w + nx + gy + mz)}{v} - t$.

* The experiments hitherto published, had left some doubt as to the true latent heat of vapour. Black first obtained the number 810°; Watt afterwards gave it 950°; Southern produced 945; Lavoisier made it rather more than 1000°; Rumford 1040.8; Despretz 955.8; Ure 1000; Thompson "more than 1000°." Watt and Clement have both established the position that the latent heat of steam, added to the sensible heat above 32°, is nearly a constant quantity. As, however, the point 32° is entirely arbitrary, and as no temperature is now *known*, at which vapour does not rise from water or ice, there is reason to suppose that in strictness, the constant—if there be one—is different from that which these experimenters have derived. If not, the latent heat of vapour must diminish below 32° as the temperature diminishes.

TABLE XII.

Experiments to determine the latent heat of Steam, employing a given weight of water in a vessel of known weight and specific

No. of Experim't.	DATE.	Kind of vessel which contained the water.	Temp. of air outside at beginning.	Air outside at the end.	Air inside of the box at beginning.	Air inside at the end.	Temp. of the water at beginning.	Temp. of water at the end.	Gain of temp. by the water.	Weight of vapour condensed.	Weight of water in the container.	Equivalent of the thermometer.	Weight of the container.
			°	°	°	°	°	°	°	grs.	grs.	grs.	grs.
1	1835. Aug. 18,	thin copper	84.	85.			75.35	86.1	10.75	347	38659	100	5178
2	"	"	83.	83.			70.9	85.75	14.85	504	38659	100	5178
3	"	"			72.25	72.6	68.75	75.75	7.	241	39305	30	5178
4	"	"			72.60	73.	70.	77.25	7.25	250	39305	30	5178
5	"	thick glass	80.45	80.67	78.5	82.	74.6	92.65	18.05	299	17112	43	12272
6	"	"	80.85	81.	81.	82.	75.5	88.	12.5	192	17112	43	12272
7	Sep. 19,	"	67.5	67.55	68.	68.	64.6	74.5	9.9	156	17428	7.3	12272
8	"	"	67.7	67.7	68.	68.	65.25	73.25	8.	127	17428	7.3	12272
9	Sep. 12,	thin glass			73.4	73.6	68.5	78.5	10.	167	18405	30	2986
10	Sep. 26,	"	60.4	60.7	60.5	61.	58.5	68.5	10.	156	17428	7.3	2986
11	Sep. 5,	thick sheet iron	81.1	81.15	81.5	82.	75.1	89.2	14.1	169	13152	43	5167
12	"	"	81.4	82.6	81.	82.	73.7	89.8	16.1	190	13152	43	5167

TABLE XII.

heat, to receive and condense the vapour as it passed from the mouth of the pipe.

Equivalent of the container.	Total equiv. of matter heated, estimated in grains of water.	Weight of water X gain of temperature.	$\frac{W \times T}{w}$	Temp. of steam on entering water.	Sensible heat lost by the steam.	Latent heat by separate experiments.	Latent heat by a comparison of different sets.	REMARKS.
grs.	grs.		°	°	°	°	°	The equiv. of the therm. which marked the temp. in first 2 expts. is only estimated approximately.
540.	39199.	421389.	1214.	214	127.5	1086.5		This expt. was made without the use of a 2d cylind. to defend the water vessel, and as it ended but little above the temp. of the air, the result must be somewhat too high.
540.	39199.	582005.	1154.7	215	129.25	1025.5		
540.	39875.	279125.	1158.2	215	139.25	1018.95		The time required to bring the water to a perfect state of uniformity in temp. after the steam was cut off, and the excess of its final temp. above that of the air, caused a slight error in defect. The container was surrounded by a pasteboard box.
540.	39875.	289094.	1156.3	214	136.75	1019.55	1037.87	
1342.5	18507.5	334060.4	1117.25	213	120.35	996.9		This expt. terminating more than 10° above the air, is evidently to be rejected for defect. The rise of temp. in the box proves this to be the case.
1342.5	18507.5	231343.	1204.82	215	127.	1077.82		The pipe was withdrawn from the water before closing the stop-cock, in order to prevent the rushing up of water.
1227.	18662.3	184756.7	1184.3	214	139.5	1044.8		Do. Therm. very small, but with a long stem to extend nearly to the bottom, formed of 59 grains of glass, & containing 42 1-2 grs. of mercury.
1227.	18662.3	149298.4	1175.5	213	139.75	1035.75	1038.51	Do.
299.	18734.	187340.	1121.8	213	134.5	987.3		The bulb of the therm. estimated approximately.
299.	17734.3	177343.	1146.8	212	143.5	1003.3	995.3	This expt. terminated 8° *above* the initial temp. of the air in the box, and began only 2° below it, consequently lost some heat, & gives a result rather too low.
586.	13781.	194312.1	1150.	213	123.8	1027.2		
586.	13781.	221874.1	1167.7	214	124.2	1043.5	1035.35	

Specific Heat by Vaporization.

Having determined the latent heat of vapour, it is not difficult to verify our preceding determinations of the specific heat, by operating in precisely the same manner as we do to obtain the temperature of a body,—except, that the temperature of the bath of melted metal is now first ascertained by the mercurial thermometer; and the actual temperature of the standard piece being then known, is compared with the weight of vapour which it produces, by cooling in boiling water from its initial temperature down to 212°. These experiments were made both before and after the screw beam and counterpoise were changed. The weight of the standard piece is, in both cases, taken in degrees of the pyrometer scale as existing at the time.

It will be seen, that, assuming as correct the determination of latent heat, made by the committee (1037°), the experiments given in the accompanying table (No. XIII.) afford results for the specific heat of iron as follows:—

1. Taking the mean of 29 experiments, it is 11325
2. Taking only those made before the screw beam was changed, (9 experiments,) we obtain 11340
3. Taking together the last 20 experiments of the table, we have 11324
4. Experiments Nos. 7 and 8 with the first screw and counterpoise, differing only in the 5th place of decimals, give .11336
5. Six out of the last 20, differing only in the fourth place, give 11356

6. The mean result of these 5 comparisons, is . . .11336

As a mean of the nine sets of experiments in different vessels, the specific heat below 212°, determined by heating water, as above detailed, was found=.113374. As the calculations just detailed are carried only to the 5th place, the two results may be considered as differing from each other only by $\frac{1}{11137}$th part of the total value.

Of those experiments which differ considerably from the general result, about the same number was found above, as below the *mean*, showing that if these discrepancies be due to errors of observation, they are, as we ought to expect, liable to be either in excess or defect; and that they counterbalance each other.

The eight experiments, of which the results differ only in the 4th place of decimals, were made at temperatures varying from 392 to 595, without indicating any decided difference in the specific heat of the metal within those limits.

Of the extreme results in the table, the highest was obtained at 480° and the lowest at 488°;—the next to the highest, at 500°, and the next to the lowest, at 292°.

From the exact conformity of the general results of the method of evaporation, and that of heating water, in trials below 212°, it appears that if the specific heat of the standard piece be determined by the latter method, and its weight be duly regulated to conform to the length of the threads of the screw beam,—and to the weight of the revolving counterpoise, its indications of temperature will be such as to connect themselves immediately with those of the mercurial thermometer.

TABLE XIII.

Experiments to determine the specific heat of the standard-piece of wrought iron used in experiments with the Steam Pyrometer during this investigation. The heating performed in a bath of mercury or melted tin, and the effect measured by the weight of vapour carried off in cooling, from the first observed temperature down to 212°.

No. of the Experiment.	DATE.	Observed temperature of the iron.	Weight of steam which escaped.	Temp. lost by the iron in the generation of steam.	Weight of the standard-piece in pyrometric units or degrees.	Weight of iron × loss of temperature.	Weight of steam × latent heat (=1037°.)	Specific heat of iron from the preceding data.	REMARKS.
	1833.	°		°					
1	July 20,	600	390	388	9065.7	3517491	404430	.11494	In the first nine experiments the heating of the standard-piece took place in the heating apparatus used in trials on the metals, and the shield to defend it in passing to the boiler was not employed.
2	"	584	366	372	9065.7	3372440	379542	.11253	
3	July 27,	562	351	350	9051.4	3167990	363987	.11478	
4	"	556	334	344	9051.4	3113881	346358	.11123	
5	"	510	280	298	9051.4	2697317	323544	.11995	
6	"	576	351	364	9051.4	3294709	363989	.11047	
7	"	590	374	378	9051.4	3421429	387858	.11335	
8	"	595	379	383	9051.4	3466686	393023	.11337	
9	"	462	240	250	9051.4	2262850	248880	.10998	
	1835.								
10	June 5,	450	278	238	10443	2485434	285500	.11487	In this experiment the thermometer attached to the boiler had fallen 2 or 3° before the condenser was put on. In this and the eleven following experiments the heating was performed in a bath of mercury.
11	"	466	280	254	10443	2652522	290360	.10946	
12	"	454	273	242	10443	2527206	283101	.11589	
13	"	470	295	258	10443	2694294	305915	.11350	
14	"	480	333	268	10443	2798724	345321	.12338	The condenser kept off till the thermometer had fallen a little.
15	"	488	325	276	10443	2882268	337025	.11693	Condenser put on sooner than in the preceding case.
16	June 13,	476	302	264	10443	2756952	313174	.11359	
17	"	435	260	223	10443	2485434	269620	.10848	
18	"	462	287	250	10443	2610750	297619	.11399	
19	"	444	262	232	10443	2422776	271694	.11200	
20	"	392	205	180	10443	1879740	212588	.11307	
21	"	292	83	80	10443	815440	86071	.10555	
22	June 20,	535	370	323	10443	3373089	383690	.11374	In this and the following experiments a bath of tin was employed to heat the standard-piece.
23	"	490	307	278	10443	2903154	318353	.10965	
24	"	500	350	288	10443	3007584	362950	.12067	
25	"	492	320	280	10443	2924040	331840	.11348	
26	"	492	310	280	10443	2924040	321470	.10994	
27	"	492	330	280	10443	2924040	342210	.11703	
28	"	492	325	280	10443	2924040	337025	.11526	
29	"	488	290	276	10443	2882268	300730	.10433	
							Mean of 29 Experiments	.11325	

Heating and cooling of liquids.

In determining the specific heat of the iron standard-piece, it became evident that the influence of the air and other extraneous objects upon the temperature of the vessel of water could not be omitted, at least while the experiments were conducted, without enclosing the container in some other vessel which might shield it from the radiating and conducting power of surrounding bodies.

But in order to neutralize, as far as practicable, the disturbing influence of the causes just mentioned, it was evident that with a given state of the air and of other bodies, the water-vessel must be made to receive during an experiment as much heat from surrounding objects as it imparted to them. This could be effected only by commencing each experiment, so much below the temperature of the air, that, during the cooling of the iron in water, the temperature of the latter should, in rising, pass through the temperature of the air, and not only rise above it, but so divide the duration of the experiment that the cooling effect of the air in the latter portion of time should precisely equal its heating influence in the former.

It, therefore, became necessary to discriminate between the respective influences of hot iron and of the air, in order that the temperature of the water might be adjusted to that of the apartment before commencing the experiment.

By an examination of table XIV. it will be perceived that in twenty-three different experiments the times of rising through different stages of temperature are given, together with the initial and final temperatures of the air and of the water. It will not fail to be observed, that in comparisons of this nature, the materials and construction of the thermometer are elements of quite as much importance as the quantity of liquid heated, or the materials and other circumstances of the container.

Thus, it will be seen, that by a mean of 8 sets of observations in which the mercurial thermometer A (calculated to be equivalent to $152.7 + 43.45$) $= 196.15$ grains of water, was employed, the time required to obtain the full effect of 6000 grains of iron heated to 212°, and cooled in water at 60 or 64 degrees, was 148 seconds.

The quantity of water was varied from 12000 to 18000 grains.

With the mercurial thermometer B, estimated at about 43 grains of water, the time by 7 sets of observations was found to be 126 seconds; the quantity of water from 13000 to 20000 grains, and the vessel either of glass or sheet iron; the two latter circumstances serving to produce comparatively little effect on the time required to bring the temperature to a stationary condition.

With the spirit thermometer C, 8 sets of observations gave a mean duration of 295 seconds, the weights of water varying from 13000 to 18000 grs., and the container being either iron, weighing 1733 grains, or glass weighing from 2,900 to upwards of 12,200 grains. This last thermometer has a bulb $6\frac{1}{16}$ inches in length, and .5 inch in diameter, weighing 264 grains; and contained about 142 grains of alcohol, which, by the mean of 8 different determinations,* has a specific heat of .641, and consequently is equivalent to 91 grains of water, and the glass to 26.4 grains, whence the whole portion immersed was equivalent to 117.4 grains of water.

*See Thompson on heat p. 76.

TABLE XIV.

Synopsis of twenty-three sets of observations in six different series on the rate of heating in given quantities of water, by the cooling of the iron standard-piece weighing 6000 grains.

1st Series in thin glass jar weighing 3325 grains.—Water 20432.					2d Series in an iron jar weighing 1733 grains. Water 13065.				
No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.	No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
Tab. IV. Exp. 22. 1	61.9	54.5° Ther.	.5°	24″	Tab. VIII. Ex. 1. 1	65.5°	60.8°	1.2°	16″
		B.	1.	8				1.	6
		Mer-	1.	13			Ther.	1.	3
		curial.	2.	30			B.	1.	3
			.6	44			Mer.	1.	3
								1.	4
Result.	61.9	59.6°	5.1	119				1.	5
								.4	4
Tab. IV. Ex. 23. 2	63.5	60.	2.	17				.1	5
		Ther.	1.	15				.1	6
		B.	1.	12				.2	11
			.4	30				.1	17
			.1	8				.1	15
			.1	7				.1	19
			.1	5					
			.1	10	Result,	66.	69.1	8.3	117
			.1	45					
Result.	63.5	64.9	4.9	149	2	68.25	59.9	2.1	21
							Ther.	2.	11
Tab. IV. Ex. 24. 3	63.5	64.9	1.1	19	Tab. VIII. Ex. 2.		B.	1.	8
		Ther.	1.	4				1.	13
		B.	1.	7				.4	7
			1.	12				.4	9
			.3	19				.2	10
			.1	11				.1	9
			.1	22				.1	11
								.1	10
Result.	63.5	69.5	4.6	94	Result,	69.5	67.3	7.4	109
Tab. IV. Ex. 25. 4	71.	67.1 Ther.	.9	19	Tab. VIII. Ex. 3.	52.5	50.6	.4	20
			1.	8			Ther.	1.	10
		B.	1.	8			C.	1.	16
			.5	8			Spirit.	1.	12
			.3	7				.4	7
			.2	6			W. 60° 12867grs.	.2	5
			.2	15				.2	4
			.2	9				.2	4
			.2	17				.2	2
			.15	30				.2	13
			.05	18				.2	2
								.2	4
Result.	73.	71.8	4.7	145				.2	7
								.2	5
Tab. IV. Ex. 26. 5	71.	67.1 Ther.	.9	15				.2	6
			1.	8				.2	9
		B.	1.	14				.2	8
			1.	18				.1	13
			.2	14				.1	5
			.3	19				.1	12
			.2	29				.1	11
			.05	14				.1	17
			.05	22				.1	28
								.08	31
Result	72.5	71.8	4.7	153	Result,	52.5	57.58	6.98	251

Remark.—The observations in this table were taken during the several series of experiments on specific heats—the temperature of the iron at each trial being 212 degrees.

TABLE XIV.—*Continued.*

3d series in a glass jar weighing 2995 grains.—Water 16947.

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
1	57.5°	56.90°	.91°	25″
		Ther.	1.	15
		C.	1.	20
		Spirit.	.5	10
			.5	12
			.5	14
			.2	7
			.2	7
			.2	9
			.1	1
			.1	8
			.1	7
			.1	5
			.1	8
			.1	6
			.1	7
			.15	24
Result.	58.	61·95	5.86	185
2	58.5	52.62	.38	13
		Ther.	1.	14
		C.	.5	10
			.5	9
			.5	11
			.5	12
			.5	11
			.2	4
			.2	7
			.2	8
			.1	2
			.1	5
			.1	6
			.1	6
			.1	5
			.1	7
			.1	5
			.1	8
			.1	11
			.1	10
			.1	13
			.1	18
			.1	25
			.1	46
			.2	59
Result.	59.	58.7	6.08	325
3	57.	52.33	.67	19
		Ther.	1.	14
		C.	1.	16
			.5	10
			.5	15
			.5	13
Carried up.			4.17	87

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
Brought forward.			4.17°	87″
			.5	15
			.2	11
			.2	13
			.1	9
			.1	9
			.1	11
			.1	15
			.1	19
			.1	34
			.11	26
Result,	57.5	58.11	5.78	249
4.	56.5	49.35	.65	15
		Ther.	1.	13
		C.	1.	14
			1.	18
			1.	22
			1.	27
			.1	10
			.1	11
			.1	13
			.1	22
			.1	31
			.1	63
			.06	205
Result,	56.5	55.66	6.31	464
5.	67.2	63.51	.49	16
		Ther.	1.	7
		A.	1.	7
		Mer.	1.	10
			1.	13
			.5	11
			.5	28
			.1	18
			.1	33
			.02	11
Result,	67.5	69.22	5.71	154
6.	67.1	63.5	.5	15
		Ther.	1.	8
		A.	1.	7
			1.	9
			1.	15
			.5	14
			.5	27
			.1	13
			.1	19
			.06	30
Result,	68.2	69.26	5.76	157

Table VI. Expt. 1.

Tab. VI. Expt. 2.

Tab. VI. Ex. 3.

Tab. VI. Ex. 2.

Tab. VI. Ex. 4.

Tab. VI. Ex. 5.

Tab. VI. Ex. 6.

TABLE XIV.—*Continued.*

4th series in glass jar weighing 12272 grains.—Expts. 1, 2, 3, 4, water 18158. Experiment 5, water 17902.

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
Tab. V. Ex. 1. 1	58.75°	52.62°	.38°	16″
		Ther.	1.	10
		C.	1.	17
		Spirit.	.5	11
			.5	13
			.5	12
			.5	16
			.2	9
			.2	12
			.1	8
			.1	7
			.1	9
			.1	12
			.1	16
			.1	29
			.1	77
			.005	39
Result,	58.5	58.105	5.485	313
Tab. V. Ex. 2. 2	57.	56.09	.91	26
		Ther.	1.	13
		C.	1.	18
			.5	14
			.5	13
			.5	15
			.5	28
			.1	12
			.1	7
			.1	9
			.1	11
			.1	15
			.1	23
			.05	10
			.05	39
			.01	37
Result,	58.25	61.71	5.62	290

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
Tab. V. Ex. 3. 3	57.75°	52.33°	.67°	21″
		Ther.	1.	14
		C.	1.	19
			1.	26
			.5	15
			.5	20
			.3	20
			.1	9
			.1	13
			.1	15
			.1	21
			.05	23
			.05	24
			.03	79
Result,	uncer.	57.83	5.50	319
Tab. V. Ex. 5. 4	67.1	63.5	1.5	24
		Ther.	1.	5
		A.	1.	9
		Mer.	1.	17
			.7	25
			.1	12
			.1	20
			.04	23
Result,	68.5	68.94	5.44	135
Tab. V. Ex. 6. 5	67.1	63.52	.48	18
		Ther.	1.	6
		A.	1.	6
			1.	9
			1.	14
			.4	12
			.1	4
			.1	5
			.1	5
			.1	10
			.1	18
			.05	27
			.02	23
Result,	67.7	68.97	5.45	157

TABLE XIV.—*Continued.*

5th series in a glass jar weighing 6923 grains.—Water 11764.

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of observat'n.	Rise of temperature in wat.	Time elapsed during the rise.
1	65.2°	60.°	1.°	10″
		Ther.	1.	5
		A.	1.	5
		Mer.	1.	6
			1.	6
			1.	7
			1.	11
			.5	9
			.5	17
			.2	13
			.1	14
			.06	34
Result.	65.7	68.36	8.36	137″
2	65.9	60.02	.98	10
		Ther.	1.	5
		A.	1.	5
			1.	5
			1.	5
			1.	8
			1.	10
			.5	9
			.5	17
			.1	6
			.1	9
			.07	52
Result.	65.7	68.27	8.25	141

Tab. VII. Ex. 4.

Tab. VIII. Ex. 5.

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of obervat'n.	Rise of temperature in wat.	Time elapsed during the rise.
3	65.°	60.01°	.99°	12″
		Ther.	3.	15
		A.	1.	6
			1.	7
			1.	9
			.5	8
			.5	12
			.1	5
			.1	6
			.15	10
			.08	35
Result.	65.3	68.38	8.37	125

Tab. VII. Ex. 6.

6th series in a thin glass jar, weighing 2469 grains—water 12243.

No. of expt. & place in specif. heat series.	Temp. of air near the water vessel.	Temp. of wat. at beg. and end of obervat'n.	Rise of temperature in wat.	Time elapsed during the rise.
1	66.1	60.	1.	11
		Ther.	1.	6
		A	1.	6
			1.	7
			1.	8
			1.	12
			1.	14
			.2	3
			.2	4
			.1	3
			.1	3
			.1	10
			.2	14
			.1	4
			.2	11
			.1	7
			.1	10
			.1	21
			.06	29
Result.	66.3	68.56	8.56	183

Tab. VII. Ex. 10.

A circumstance which deserves attention in examining this table, is, that a few hundredths of a degree in rise of temperature, often required, at the commencement of an experiment, a much longer time than in the periods immediately following. In fact, it was sometimes observed, that the plunging of the hot iron into the water, was accompanied by an instantaneous minute depression of the liquid in the thermometer; subsequent to which, a stationary period occurred, and then a rapid rise—as indicated by the observations in the accompanying table. This phenomenon is to be ascribed to the sudden expansion of the glass composing the bulb of the instrument, by the first impression of the heat, affording an enlarged cavity for the liquid, before the latter begins to feel the same influence, and consequently to expand. This effect is the more striking, the greater is the difference of temperature to which the instrument is suddenly exposed. It needs hardly be mentioned that the opposite effect of a rise in the liquid,

accompanies the sudden immersion of the thermometer in a mass of fluid colder than itself.

It is also worthy of remark, that the time required by the thermometer to attain the same final temperature as the liquid in which it is plunged, is greater than that employed by the iron in giving up its excess of heat to the same liquid. This will generally require some deduction from the total observed time, in order to arrive at the true time of cooling of the standard piece.

The deduction will be less, the more sensible is the thermometer. Experiments with thermometer B, require less correction than those made with A, and the latter less than those with C.

Owing to the fact just stated it is not always easy to determine the precise moment when observations ought to cease; consequently, the last rise noted may, for our present purpose, often be rejected, when the amount observed does not exceed 5 or 6 hundredths of a degree, and the remaining time taken as the true duration of the cooling. By the aid of these observations, we shall be enabled to determine, very nearly, the relation between the respective *augmentations* of temperature in the water, and the *times* in which they severally occur. The more exact determination would require that the standard piece and the thermometer should be either both rapidly moving, or both at rest in the same relative positions, for every experiment. It was easily perceived that no slight influence might, in the earlier parts of the process, be ascribed to these circumstances.

An inspection of the table, shows that the general relation to which we have referred, is such, that *two-thirds of the change of temperature in the water, occurs during the first-third of the entire period of observation* This supposes the proper *correction* to have been applied to the latter as above pointed out.

Thus in experiment 3, table VIII., thermometer C gave a change of temperature 6.98°, two-thirds of which is 4.66°. During the time of the 10th observation, the rise of temperature came to 4.66°, and the time then elapsed was 84″ from the beginning, the *whole time* being 251″. Difference .33″.

In table VI., experiment 3, with the same thermometer, we have a total rise of 5.78° in 249″. Two-thirds of 5.78° is 3.85°, and one-third of 249″ is 83″. It appears that a rise of 3.85° had been attained during the sixth observation, and that at the moment when this took place, the time elapsed was 78.7″. Difference 4.3″

Again in table V., experiment 2, with the same thermometer, the total time was 290″; but the last observation gave a change of only $\frac{1}{100}$ of a degree in 37″. This being omitted, we have the time 253″, and the change 5.61°, two-thirds of which is 3.74°. One-third of the time is 84.3″. The observations prove that a rise of 3.74° took place during the 5th observation when the total time elapsed was 79.58″. Difference 4.72″.

When thermometer A was used, in experiment 5, table VI., a gain of 5.71° took place in 154″. The last $\frac{2}{100}$ of a degree required 11″; this being omitted, we have 5.69° in 143″. Two-thirds of 5.69 is 3.78; which by observation was attained in 44″, whereas the calculation would give 47.6″. Difference 3.6″.

With the same thermometer used in experiment 10, table VII., it appears that the total time, exclusive of 29″ taken up in rising through the last $\frac{6}{100}$ of a degree, was 154″, one-third of which is 51.3″. The total rise in this time was 8.5°, two-thirds of which is 5.67°, which by observation was attained in 46″. Difference 5.3″.

The thermometer B, of which the action was more prompt than that of either of the others, gives results more nearly agreeing with the law above stated. Thus in table IV., experiment 24, we find a rise of 4.6° in 94″. Two-thirds of 4.6° is 3.06°, and one-third of 94″ is 31.3″. By observation 3.06° had been attained in a trifle less than 30″. Difference 1.3″.

Again, in table VIII., experiment 2, a rise of 7.4° took place in 109″, one-third of which is 36.3″. The observation shows that a rise of 4.72° had been attained in 37″. Difference .7″.

If in table VII. experiment 4, thermometer A, we omit the time of the last observation, we have a gain of 8.36° in 103″.—Two-thirds of 8.36° is 5.57°, this rise of temperature had occurred at the end of 35″ by observation—whereas by calculation we should have 34.3″. Difference .7″.

In table VII. experiment 5, we obtained a gain of 8.25° of temperature in 141″. Two-thirds of 8.25° is 5.5°. This last number of degrees had been gained by the water about the middle of the 6th observation, or when the time from the commencement was 34″. As the last $\frac{7}{100}$ of a degree required 52″, we may safely attribute to the sluggishness of the thermometer the same retardation as in the preceding experiment; in which case we should have the total time 107″, one-third of which gives the calculated time for a rise through two-thirds the range equal to 35.6″, and the difference between the observed and the calculated times=1.6″.

In table VII. experiment 6, two-thirds of the gain of temperature was observed to have taken place at the end of 37″. The total time during which observations were made, was 125″, and as this time is much less than either of the two preceding, we may suppose that a less allowance is required for the tardiness of the thermometer, in consequence, perhaps, of more rapid agitation in the liquid while the latter received its augmentations of temperature. Hence if we deduct 15″ we have remaining 110, one-third of which is 36.6″ for the calculated time of attaining two-thirds of the gain of temperature. Difference .4″.

In table IV. experiment 25, we found that a gain of 4.7° was effected in 145″, the last 18 of which were taken up in raising the thermometer B. $\frac{5}{100}$ of a degree. Omitting this period, we have a remainder of 127″, one-third of which is 42.3″. Two-thirds of 4.7° is 3.14°, which, on inspecting the column of *rise of temperature*, we find was produced in 38.8″ from the time of beginning. Hence the calculated exceeds the observed time by 3.5″.

Of these eleven comparisons it will be observed that eight give the time by observation for two-thirds rise of temperature less, by a small amount, than one-third of the total time, while the others give the former greater than the latter quantity. The mean result, however, is a difference of only 1.5″. The results might probably be found to conform more exactly to the law, if the liquid were indefinite in quantity, and its rise indefinitely small, compared with the number of degrees through which the iron cooled.

Heating by Contact of Air.

The result just obtained, combined with another on the rate of heating of the vessels of liquid exposed to the action of air, will show on which of the experiments the greatest reliance is to be placed, as exhibiting the true specific heat of iron, without requiring a deduction for the influence of air.

The manner of performing these experiments, has been already adverted to. It consisted merely in filling the cylinders with water of a low temperature, and inserting in them, the same thermometers which had been used in experiments on specific and latent heat; placing other thermometers outside of the cylinders, to mark the temperature of the air.

The time of arriving at, and of leaving each mark on the scale, was then noted; and the mean taken as the point of time for attaining each degree.

Table XV. contains the result of these observations. The first 9 are, perhaps, from the particular attention directed to them, deserving of the most confidence, and from these it appears that *the rate of heating or of cooling, of a mass of liquid acted on by the air at a higher or a lower temperature, is directly and simply proportional to the difference of temperature between the liquid and the air.**

This is no more than a verification of the Newtonian law which is well known to be sensibly true only for very moderate differences, such as those observed by the committee which never exceeded 20°. The same law is also well known to fail entirely, when carried to very great differences. Assuming then the correctness of our result it enables us to determine, that while the iron in experiments on specific heats, was imparting its excess of heat to the water, *the air gave to the liquid as much heat as it received from it, whenever the initial temperature of the water was twice as much below that of the room as the final temperature was above it.*

* This results from a mean of 14 comparisons between the differences of temperature, and the corresponding times of heating through a given indefinitely small range of temperature, as one-tenth of a degree, by the formula $D^x : d^x :: t : T$. Where D and d are observed differences of temperature, between the water and the air, t and T the corresponding numbers of seconds required to raise the temperature 0.1°; and x the power of the difference of temperature according to which the times vary. These fourteen comparisons give a mean value of $x = 1.002$.

TABLE XV.

Comparative table showing the rate of heating or of cooling of given liquid masses in vessels of different sizes, by exposure in an atmosphere of known temperature.

No. of the Experiment.	DATE.	Weight of water.	Kind of containing vessel.	Initial temperature of the water.	Initial temperature of the air.	Final temperature of the water.	Final temperature of the air.	Mean difference of the air and water.	Time elapsed during the observation.	Amount of change in temperature.	Time required to produce a change of 1-10 of a degree.	Remarks.
	1835.		thin									Thermometer B. mercurial = 4
1	Jan. 10.	20432	glass cylin.	69.7	63.°	69.2	63.°	6.45	640.″	–°.5	128.″	.7 grains of
2	··	20432	wght 3325 grs.	69.8	62.2	69.4	62.2	7.4	460.	–°.4	115.	water.
3	Jan. 17.	20432		41.	61.5	42.	61.5	20.	435.5	1.°	43.55	
4	··	20432		42.	61.5	44.	61.6	18.55	895.	2.	44.75	
5	··	20432		44.	61.6	46.	61.8	16.7	945.5	2.	47.25	
6	··	20432		46.	61.8	48.	61.8	14.8	1302.	2.	65.1	
7	··	20432		48.	61.8	50.	61.6	12.7	1273.5	2.	63.675	
8	··	20432		50.	61.6	52.	61.5	10.55	1534.	2.	76.7	
9	··	20432		52.	61.5	54.	61.9	8.7	1912.5	2.	95.625	
	1834.											During this
10	Dec. 8.	20274		70.2	74.5	70.3	74.5	4.25	37.5	.1	37.5	and the 2
11	··	20274		70.4	73.	70.5	73.	3.55	35.	.1	35.	following a
12	··	20275		70.75	73.	70.85	73.	2.20	40.	.1	40.	brisk fire
13	··	20275		70.5	73.	71.6	73.	1.45	45.	.1	40.	was kept up
14	··	20275		69.15	73.5	69.25	73.5	4.32	25.	.05	50.	in the stove.
	1835.		thin									The largest
15	Mch. 22.	12676	iron cylin.	50.93	64.	51.	64.	13.03	40.	.07	57.	therm. (A)
16	··	12676	1733	51.	64.	51.1	64.	12.95	101.	.1	101.	was used in
17	··	12675	grs.	51.1	64.	51.2	64.	12.85	125.	.1	125.	this & 4 fol-
18	··	12675		51.2	64.	51.3	64.	12.75	109.	.1	109.	lowing=196
19	··	12675		51.3	64.	51.5	64.	12.6	175.	.2	87.5	grs. water. Water ves- sel in tin one, 14 inches high.
			thin									In this & 9 following expts. the spirit thermometer C was used.
20	Feb. 21.	16728	glass jar	55.975	57.	55.99	57.3	1.018	103.	.015	687.	
21	··	16728	2996	55.99	57.3	56.035	57.6	1.287	63.	.045	140.	
22	··	16728	grs.	56.035	57.6	56.05	57.0	1.557	35.	.015	233.	
23	··	16728		50.05	57.9	56.06	58.2	1.845	65.	.01	650.	
24	··	16728		56.06	58.2	56.09	58.5	2.125	172.	.03	573.	
25	··	16728		52.29	58.5	52.33	58.5	6.29	126.	.04	315.	
26	··	16728		52.33	58.5	52.44	58.5	6.115	72.	.11	65.	
27	··	16728		52.44	58.5	52.50	58.5	6.03	60.	.06	100.	
28	··	16728		52.50	58.5	52.55	58.5	5.975	107.	.05	214.	
29	··	16728		52.55	58.5	52.61	58.5	5.91	68.	.06	213.	
			thin									Therm. B.
30	Feb. 7.	12676	iron cylin.	59.7	68.	59.8	68.25	8.375	61.	.1	61.	No enclos-
31	··	12676	1733.	59.8	68.25	59.9	68.25	8.40	47.	.1	47.	ing tin cylinder used

Strength of rolled copper.

Tables numbered from XVI. to XXIII. inclusive present the results of experiments on the strength of boiler copper, both at ordinary and at elevated temperatures. From these tables it appears that at temperatures varying from 62 to 82 degrees Fah., the strength of rolled copper is by a mean obtained from 66 experiments on 8 different specimens within those limits, equal to 32826 pounds to the square inch. The *irregularities* of strength vary in the different specimens from $1\frac{9}{10}$ to $4\frac{8}{10}$ per cent. of the mean tenacity of the specimen in which they occur, and the mean value for the 8 bars is $3\frac{3}{10}$ per cent. The strips of copper as received from the manufacturers were of 4 different thicknesses, two of each thickness, and they were reduced by filing to a nearly uniform size throughout their whole length. By an attentive observation, it will be seen that the thicker specimens give in general the higher results.

Thus, No. 1, of which the original thickness was two-tenths of an inch, (called by the manufacturers three-sixteenths,) broke at eight trials, with an average force of 30704 lbs. per square inch.

No. 2, with the same thickness, broke with 31468 lbs. as the average weight, at seven different trials. Hence the mean strength of these two bars is 31086 lbs. per square inch.

Nos. 3 and 4, the thickness of which was a "*scant quarter*" of an inch, broke, the former at ten trials, with 33428 lbs., and the latter at six trials, with 33243 lbs., giving a mean of 33335.

Nos. 6 and 7, having a thickness differing but little from the two preceding, but rather greater, gave, the one at seven trials, 33411, and the other at nine, 33005 lbs. per square inch; or, as a mean of the two specimens, 33205.

Nos. 5 and 8, with a thickness before filing of not less than .27 of an inch, exhibited a tenacity of 33771 and 33780 lbs., the former being the mean of eleven and the latter of eight successive trials, showing a mean of 33775.

The manufacturers have not, in their note accompanying the specimens, referred to any difference either in the kind of pig metal, the melting and refining which took place previous to rolling, or in any other circumstance attending the manufacture of the different bars, which could lead the committee to assign a probable cause for the difference in point of cohesion between the respective pairs.

That difference between Nos. 5 and 8, and 1 and 2, is no less than 3071 lbs. per square inch, or 9.3 per cent. of 32836, which we have found to be the average strength of eight specimens.

But, as already stated, the irregularities observed in any one specimen, did not exceed $4\frac{8}{10}$ per cent. of its mean strength. It seems therefore probable, that in reducing the lighter specimens to their final thickness, the operation was extended so far as to reduce below a proper point the temperature of the copper, and thus to injure its texture. It will be seen that the highest results obtained by the committee, are almost identical with that given by Mr. Rennie.

In every calculation of the strength of materials for a steam boiler, the *least strength* known to be possessed by any part of the sheet, is that which alone can be relied on for fixing the pressure to which it may be subjected.

For *copper*, at ordinary temperatures, the lowest result obtained by the committee was 30406 lbs. per sq. inch, and the mean minimum for the 8 bars 32146 pounds. To other temperatures subsequent developements apply.

TABLE XVI.

Experiments on copper bar No. 1, manufactured by John M'Kim, Jr., & Sons of Baltimore, from South American pig, melted, refined and rolled into boiler-plate $\frac{3}{16}$ inch thick;—cut off with the shears one

Marks.	Breadth.	Thickness.	Area of sections at the points measured before trial.	No. of the Experiment.	DATE.	Area of the sections of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
0	.753	.192	.144576		1833.	sq. in.	°	lbs.		
1	.751	.189	.141939	1	Nov. 7.	.146412	57.5	159.5	4785	239.
2	.751	.194	.145694							
3	.750	.196	.147000							
4	.750	.196	.147000							
5	.752	.196	.147392							
6	.758	.196	.146608	2	"	.146711	120.?	154.	4620	231.
7	.748	.198	.148104							
8	.748	.197	.147356							
9	.748	.197	.147356							
10	.748	.197	.147356							
11	.747	.197	.147159	3	"	.144836	100.?	156.5	4695	234.7
12	.747	.196	.146412							
13	.746	.195	.145470							
14	.745	.196	.146020	4	"	.145015	95.?	154.5	4635	231.7
15	.745	.195	.145275							
16	.743	.197	.146371	5	"	.147114	90.?	157.	4710	235.5
17	.743	.198	.147114							
18	.746	.195	.145470	6	Nov. 9.	.147000	392.	135.	4050	202.5
19	.744	.195	.145080							
20	.743	.195	.144885							
21	.743	.195	.144885	7	"	.143407	75.	153.	4590	229.5
22	.742	.195	.144690							
23	.742	.196	.147392							
24	.747	.196	.146412	8	Nov. 14.	.147356	392.	135.125	4054	202.7
25	.747	.196	.146412							
26	.743	.197	.146371							
27	.742	.196	.147392	9	"	.147356	68.75	157.5	4725	236.2
28	.740	.196	.145040							
Mean of 29=			.146146	10	"	.145705	68.75	159.75	4792.5	239.62
Maximum			.148104							
Minimum			.141939	11		.146706	69.	159.	4770	238.5
Mean of the 2			.145021		Mean of 11 =	.146147				
Diff. of the 2			.006165							

TABLE XVI.

{ *inch wide, filed to the size recorded, marked and gauged at every inch.*
Specific gravity 8.9866.

Effective strain.	Strength in pounds per square inch.	Weights producing extension.	Extension observed.	Point of fracture.	REMARKS.
4516.	31049	112. 119. 141.5	None. $\frac{1}{3.6}$ inch. 1 inch.	No. 24½	The piece broken off had been elongated from 7 to 9.6 inches = 1 inch for every 2.69.
4389.	29916			" 26⅓	Heated probably to the temperature noted, by the machine which had been used in a hot experiment just before this trial, fracture took place in the piece stretched in the preceding experiment.
4460.3	30795			" 21¼	Fracture oblique across the thickness of the bar.
4403.3	30364			" 19⅓	Same piece as above.
4474.5	30415			" 17	
3847.5	26173			" 3¾	Part in hot oil from 2½ to 5½.
4360.5	30406			" 0½	
3851.3	26136			" 9	
4488.8	30467			" 10	
4552.88	31247			" 12¾	
4531.5	30888			" 5⅞	The mean area of the 11 sections of fractures is .000001 square inch greater than the mean area of the 29 measured sections.

TABLE XVII.

Experiments on copper bar No. 2, manufactured by John M'Kim, jr., & Sons, of Baltimore, from South American pig, melted, refined and rolled into boiler plate three-sixteenths of an inch thick, cut off with the

Marks.	Breadth.	Thickness.	Area of section before trial.	DATE.	No. of the Experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.
0	.723	.198	.143154							
½	.713	.198	.141174							
1	.724	.197	.142628	1833,						
1½	.735	.197	.144795	Dec. 31,	1	.139895	63.5	153.5	4605.	230.
2	.720	.196	.141120							
2½	.721	.194	.139874							
3	.742	.199	.147658							
3½	.745	.200	.149000							
4	.744	.195	.145080	1834.						
4½	.722	.195	.140790	Jan. 4,	2	.145446	32.	159.75	4792.5	239.
5	.719	.195	.140205							
5½	.720	.195	.140400							
6	.720	.200	.144000	"	3	.143273	32.	160.25	4807.5	240.
7	.720	.195	.140400							
8	.724	.198	.143352							
9	.728	.199	.144872	"	4	.140451	32.	159.	4770.	238.5
10	.732	.197	.144204							
11	.732	.197	.144204	"	5	.143023	32.	159.	4770.	238.5
12	.736	.200	.147200	"	6	.140400	32.	159.	4770.	238.5
13	.739	.198	.146322	"	7	.142560	32.	159.	4770.	238.5
14	.738	.198	.146124	"						
15	.737	.198	.145926							
16	.732	.198	.144936	"	8	.143352	32.	161.	4830.	241.5
17	.720	.198	.142560							
17½	.713	.197	.140461	"	9	.145926	32.	161.	4830.	241.5
18	.713	.196	.139748							
19	.714	.196	.139944	Jan. 11.	10	.141424	62.5	158.25	4747.5	237.
20	.723	.197	.142431							
21	.729	.200	.145800							
22	.728	.198	.144144							
23	.729	.199	.145071							
24	.728	.199	.144872							
25	.735	.197	.144795	"	11	.144872	62.5	159.5	4777.5	238.
26	.737	.200	.147400							
27	.730	.199	.145270							
				"	12	.144872	62.5	160.	4800.	240.
Mean of 35 = .143711				"	13	.146868	62.5	163.25	4897.5	244.
Maximum .149000				"	14	.145702	62.5	160.25	4807.5	240.
Minimum .139748				"	15	.146075	62.5	160.25	4807.5	240.
Mean of the 2 = .144374										
Diff. of the 2 = .009252					Mean of 14 =	.143519				

TABLE XVII.

shears one inch wide, filed to the size recorded, marked and gauged at every inch, and in some parts to every half inch. Specific gravity 8.9866.

Effective strain.	Strength in pounds per square inch.	Temp. of the room.	Weight producing elongation before fracture.	Elongation observed.	Point of fracture.	REMARKS.
			lbs.			The filing of this bar being less accurate than of others it was gauged in part at half inch distances. The space between the wedges, and on which the elongations were measured, was 25 inches.
			112.	1st permanent		
			126.	.35 inch	No.	
4375.	31273		133.	1.12 "	18¾	
			140.	2.00 "		
			143.5	2.50 "		
			147.	3.10 "		
			153.5	Broke.		
4553.5	31307	59.5°			25¼	Part in *ice* from 22 to 25. Broke just without the *ice*.
4567.5	31870	59.			20¼	The part fractured must have been between 59° and 32°—same part in ice as above.
4531.5	32264	59.			17¾	Part in ice from 8 to 11 inclusive.
4531.5	31684	59.			0¼	Part in ice from 11 to 14 inclusive.
4531.5	32272	59.			5½	Do.
4531.5	31787	59.			17	Broke near the end.
4588.5	32007	59.			8	Part in ice from 10 to 13 inclusive.
4588.5	31444	59.			15	Broke outside of the ice. No fracture has taken place *in ice*.
4510.5	31893				4¾	The following experiments were made on the remaining short pieces at the temperature of the room, not being long enough for trial in ice.
4539.5	31334				24	Reduced but not broken at 24. When it appeared about to break, 5¼ lbs. were taken off to prevent immediate fracture. One pound restored broke the bar instantly.
4560.	31476				24	
4653.5	31685				26¼	
4567.5	31348				11½	
4567.5	31268				14¼	The mean area of the 14 sections of fracture is .000192 sq. inch less than the mean area of the 35 measured sections.

TABLE XVIII.

Experiments on copper bar No. 3., manufactured by John M'Kim, Jr., & Sons, of Baltimore, from South American pig, melted, refined and rolled into boiler plate, scant ¼ of an inch thick; cut off with the

Marks.	Breadth.	Thickness.	Area of section before trial.	DATE.	No. of experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.
0	.708	.245	.173460	1833.	1	.164000	65.5	193.75
1	.708	.245	.173460	Dec. 8.				
2	.700	.245	.171500					
3	.695	.244	.169580	"	2	.166970	65.5	194.75
4	.686	.246	.168756					
5	.678	.241	.163398					
6	.688	.241	.165808	"	3	.169031	65.5	195.25
7	.690	.243	.167670					
8	.695	.245	.170275					
9	.700	.244	.170800	"	4	.171260	65.25	195.25
10	.700	.245	.171500					
11	.700	.240	.168000					
12	.700	.243	.170100	"	5	.173460	66.	196.5
13	.710	.240	.170400					
14	.710	.242	.170820					
15	.710	.246	.174660	"	6	.168000	122.	194.25
16	.712	.243	.173016					
17	.712	.244	.173728					
18	.712	.243	.173016	Dec. 15.	7	.170800	56.	195.
19	.711	.242	.172062					
20	.712	.243	.173016					
21	.712	.241	.175992	"	8	.165808	56.	195.25
22	.713	.245	.174685					
23	.713	.244	.173972					
24	.713	.243	.173259	"	9	.170760	124.	201.75
25	.713	.240	.171120					
26	.711	.240	.170640					
27	.708	.238	.168504	Dec. 22.	10	.173700	124.	198.75
Mean of 28 =			.171028					
				"	12	.172062	126.	199.75
Maximum			.174685					
Minimum			.163398					
				"	11	.172541	61.5	201.25
Mean of the two			.169041					
Diff. of the two			.011287	"	13	.173259	61.5	200.
				"	14	.173372	61.5	198.75
				Mean of 14 =		.170358		

TABLE XVIII.

shears one inch wide, filed to the size recorded, marked and gauged at every inch. Specific gravity 8.7891.

Breaking weight X leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Point of fracture.	REMARKS.
5812.5	290.6	5521.9	33670	No. 5¼	
5842.5	292.61	5550.4	33242	" 4⅓	
5857.5	292.8	5564.7	32921	" 3⅓	
5857.5	292.8	5564.7	32494	" 2⅞	
5895	294.7	5600.3	32286	" 0¼	
5827.5	291.3	5536.2	32949	" 11	Nos. 11, 12 and 13 in oil bath.
5750	292.5	5557.5	32538	" 9	A part which had been griped by the wedges remained unbroken, betraying no unusual weakness.
5857.5	292.87	5564.8	33561	" 6	Broken where it had been griped before.
6052.5	302.6	5749.9	33672	" 25¾	Broke *in oil.*
5962.5	298.1	5664.4	32610	" 14¾	Broke just outside of the oil bath—part included being from 15 to 18.
5992.5	299.6	5692.9	33086	" 19	Broke *in the oil.*
6037.5	301.8	5735.7	33242	" 20⅓	
6000	300	5700	32899	" 24	
5962.5	298.1	5664.4	32672	" 17½	Torn off by the wedges.
					The mean area of the 14 sections of fracture .000670 square inch *less* than the mean area of the 28 sections measured.

TABLE XIX.

Experiments on copper bar No. 4. Manufactured by John M' Kim, Jr., and Sons of Baltimore, from South American pig, melted, refined and rolled into boiler plate, scant $\frac{1}{4}$ of an inch thick, cut off with the

Marks.	Breadth.	Thickness.	Area of section before trial.	Elastic. tried before 1st frac. Weight producing elongation.	Total recoil.	Elasticity of the machine.	Elasticity of the bar.	DATE.	No. of the experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.
0	.717	.240	.172080	$104\frac{1}{4}$	10						
1	.717	.240	.172080	$174\frac{1}{4}$	20						
2	.717	.240	.172080	$244\frac{1}{4}$	30			1834.			
3	.717	.237	.169929	$314\frac{1}{4}$	$38\frac{1}{2}$			May 10.	1	.169455	69°
4	.715	.237	.169455	$384\frac{1}{4}$	44						
5	.715	.237	.169455	$454\frac{1}{4}$	52						
6	.711	.237	.168507	$524\frac{1}{4}$	57						
7	.718	.237	.170166	56	$59\frac{1}{2}$						
8	.721	.237	.170877	63	68						
9	.725	.237	.171825	70	73			"	2	.171914	844
10	.728	.237	.172536	77	79						
11	.729	.237	.172773	84	$87\frac{1}{2}$						
12	.732	.237	.173484	91	93			May 17.	3	.175311	1016
13	.732	.237	.173484	98	97						
14	.732	.237	.173484	105	102			"	4	.178147	1032
15	.732	.237	.173484	112	104						
16	.733	.240	.175920	119	114						
17	.735	.240	.176400	126	117						
18	.738	.240	.177120	133	125			May 24.	5	.179700	81.5
19	.740	.240	.177600	140	132						
20	.740	.238	.176120	143.5	128.5						
21	.740	.238	.176120	147	129			"	6	.178560	81.5
22	.742	.241	.178822	154	133						
23	.743	.240	.178320	$157\frac{1}{2}$	144						
24	.748	.240	.179520	161	137			"	7	.176160	81.5
25	.749	.240	.179760	$164\frac{1}{2}$	152						
26	.744	.240	.178560	$164\frac{1}{2}$	$147\frac{1}{2}$	$100\frac{1}{3}$	47′	"	8	.176490	81.5
27	.744	.240	.178560								

The last of the above observations was made when the bar had been under strain one week, after which the extension in 27 inches had become $\frac{22}{100}$ of an inch.

The elasticity was now taken several times, the mean being $147\frac{1}{2}$. The elasticity of the machine under the same weight, was found to be $100\frac{1}{3}$ hence that of the copper bar was 47′.

								"	9	.172358	81.
								"	10	.173484	81.
								"	11	.173484	81.
								May 31.	12	.168981	69.5
								"	13	.168922	69.5
								"	14	.172080	69.5
								Mn. of 14 =		.173932	

Mean of 28 = .174233

Maximum .179760
Minimum .168507

Mean of the two = .174133

Diff. of the two .011253

TABLE XIX.

shears one inch wide, filed to the size recorded, marked and gauged at every inch. Specific gravity 8.7388.

Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Point of fracture.	REMARKS.
130.5	3915.	195.7	3719.3	21948	No. 4.	The elasticities of the machine having been taken more than two years before these experiments were made, were found to have varied so much as to render useless any attempt to decide, from the trials now made, the successive elasticities of the bar.
101.5	3045.	152.2	2882.8	16768	" $9\frac{1}{8}$	
68.	2040.	102.	1938.	11054	" $15\frac{3}{4}$	
68.	2040.	102.	1938.	10878	" $21\frac{3}{4}$	
200.5	6015.	300.75	5714.25	31798	" $24\frac{3}{4}$	This part had been heated in a former trial.
203.25	6097.5	304.88	5792.62	32440	" $26\frac{1}{2}$	
200.	6000.	300.	5700.	32357	" $16\frac{1}{2}$	Heated at this section in experiment 3d.
200.	6000.	300.	5700.	32296	" $19\frac{3}{4}$	Heated in experiment 4th.
201.	6030.	301.5	5728.5	33236	" $9\frac{3}{4}$	Heated in experiment 2d.
201.25	6037.5	301.87	5735.63	33061	" $13\frac{1}{2}$	
201.75	6052.5	302.62	5749.88	33143	" 12	
196.25	5887.5	294.37	5593.13	33099	" $5\frac{1}{2}$	
198.5	5955.	297.75	5657.25	33490	" $6\frac{1}{4}$	
198.25	5947.5	297.37	5650.13	32834	" 1	
						The mean area of the 14 sections of fracture .000301 square inch *less* than the mean area of the 28 measured sections.

TABLE XX.

Experiments on copper bar No. 5. Manufactured by John M' Kim, Jr., & Sons, of Baltimore, from South American pig, melted, refined, and rolled into boiler plate full $\frac{1}{4}$ inch thick, cut off with the shears 1 inch

Marks.	Breadth.	Thickness.	Area of section before trial.
0	.778	.260	.202280
1	.774	.264	.204336
2	.764	.265	.202460
3	.766	.263	.201458
4	.768	.264	.202752
5	.767	.267	.204789
6	.767	.267	.204789
7	.767	.269	.206323
8	.767	.267	.204789
9	.768	.267	.205056
10	.770	.267	.205590
11	.770	.267	.205590
12	.771	.267	.205857
13	.771	.266	.205086
14	.770	.263	.202510
15	.770	.265	.204050
16	.773	.260	.200980
17	.772	.263	.203036
18	.772	.263	.203036
19	.772	.264	.203808
20	.772	.268	.206896
21	.768	.268	.205824
22	.761	.267	.203187
23	.758	.266	.201628
24	.755	.267	.201585
25	.767	.265	.203255
26	.769	.266	.204554
27	.770	.267	.205590
	Mean of 28=		.203967
	Maximum		.206323
	Minimum		.200980
	Mean of the 2=		.203651

.005343 differ.

No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature. Fah.
	1834.		
1	Jan. 25.	.202407	472
2	Feb. 1.	.205279	472
3	"	.201585	80 ap.
4	"	.204229	64
5	"	.203846	64
6	"	.203023	64
7	"	.203036	64
8	"	.206092	64
9	Feb. 8.	.204280	482
10	"	.202210	60
11	"	.202929	60
12	"	.204789	60
13	"	.205790	60
14	"	.204789	60
	Mean of 14=	.203877	

TABLE XX.

wide, filed to the dimensions recorded, marked and gauged at every inch. Specific gravity 8.7857.

Breaking weight in the scale.	Br. wt. × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.	Point of fracture.	REMARKS.
192.	5760.	288.	5472.	27031	No. 22½	Part in oil from 20° to 24°. The thermometer was noted at the time 482, but on being re-graduated was found 10 degrees too high at this point.
195.75	5872.5	293.6	5578.9	27128	" 12¾	
238.5	7155.	357.75	6797.25	33719	" 24	
246.25	7387.5	369.87	7017.63	34361	" 25¾	
241.25	7237.5	361.87	6875.63	33729	" 21¾	
240.5	7215.	360.75	6854.25	33761	" 14½	
241.75	7252.5	362.62	6889.88	33932	" 17⅞	Fracture remote from the wedges.
242.75	7282.5	364.17	6918.33	33569	" 20¾	
191.75	5752.5	287.62	5464.88	26752	" 4¼	
240.75	7222.5	361.12	6861.38	33931	" 24	
240.75	7222.5	361.12	6861.38	33812	" 1¾	
241.	7230.	361.50	6869.5	33544	" 5	
241.75	7252.5	362.62	6889.88	33480	" 11¾	
241.75	7252.5	362.62	6889.88	33644	" 8	Sooner parted than the preceding. Weight may have been a trifle too great.
						The mean area of the 14 sections of fracture .000090 square inch *less* than the mean area of the 28 measured sections.

TABLE XXI.

Experiments on copper bar No. 6. Manufactured by John M'Kim, Jr., and Sons, of Baltimore, from South American pig, melted, refined and rolled into boiler plate, full ¼ of an inch thick, cut off with the

Marks.	Breadth.	Thickness.	Area of section before trial.	DATE.	Number of Experiment.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.
0	.737	.253	.186461	1834.				
1	.737	.253	.186461	Feb. 15.	1	.186113	545	166.
2	.736	.253	.186208					
3	.736	.253	.186208	"	2	.186271	70	213.5
4	.733	.253	.185449					
5	.733	.253	.185449					
6	.733	.253	.185449	"	3	.186461	66	215.25
7	.733	.253	.185449					
8	.733	.253	.185449					
9	.733	.253	.185449	Feb. 22.	4	.186043	561	163.5
10	.736	.253	.186208					
11	.736	.253	.186208					
12	.736	.253	.186208	"	5	.185449	71	210.5
13	.736	.253	.186208					
14	.735	.253	.185955	"	6	.185449	71	210.5
15	.735	.253	.185955					
16	.735	.253	.185955	"	7	.186208	70	214.5
17	.735	.253	.185955					
18	.735	.253	.185955					
19	.735	.253	.185955	"	8	.185955	801	123.
20	.735	.253	.185955					
21	.735	.253	.185955					
22	.735	.253	.185955	March 1.	9	.185955	62	216.75
23	.735	.253	.185955					
24	.735	.253	.185955	"	10	.185955	61	218.25
25	.736	.253	.186208					
26	.736	.253	.186208	"	11	.185955	60	219.75
27	.736	.253	.186208					
				"	12	.186208	59	219.75
	Mean of 28 = .185964							
				"	13	.186208	58	220.
	Maximum .186461							
	Minimum .185449							
	Mean of the 2 = .186455			March 8.	14	.185955	70	218.
	Differ. of the 2 = .001012				Mean of 14 =	.186013		

TABLE XXI.

{*shears one inch wide, filed to the dimensions recorded, marked and gauged at every inch. Specific gravity* 8.9666.

Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Point of fracture.	REMARKS.
4980	249.	4731.	25120	No. 3⅞	Broke in tin; part immersed (from 2 to 6 inclusive.)
6405	320.	6085.	32666	" 1¼	
6457.5	322.8	6134.6	32900	" 0	
4905	245.2	4659.8	25047	" 9¼	Broke in tin; part immersed from 8 to 11½.
6315	315.7	5999.2	32350	" 8	Embraced in the preceding hot portion.
6315	315.7	5999.2	32350	" 5½	Had been heated.
6435	321.7	6113.25	32830	" 27	Not tried before.
3690	184.	3506.	18851	" 18¼	Very little extended before fracture.
6502	325.	6177.	33218	" 20	A portion formerly gripped by the wedges, is embraced within this part of the bar, but does not give way, proving that the action of the machine on such parts does not weaken the material.
6547	327.	6220.	33443	" 21½	
6592	329.	6263.	33682	" 23	
6592	329.	6263.	33634	" 25½	Fracture at a place formerly heated.
6600	330.	6270.	33672	" 13	
6540	327.	6213.	33401	" 16½	The mean area of the 14 sections of fracture .000049 *greater* than the mean area of the 28 measured sections.

TABLE XXII.

Experiments on copper bar No. 7. Manufactured by John M'Kim, Jr., and Sons, of Baltimore, from South American pig, melted, refined and rolled into boiler plate, full $\frac{1}{4}$ of an inch thick. Cut off with the

Marks.	Breadth.	Thickness.	Area of sections at the points measured before fracture.
0	.743	.248	.184264
1	.743	.246	.182778
2	.744	.248	.184512
3	.744	.248	.184512
4	.744	.249	.185256
5	.743	.249	.185007
6	.743	.249	.185007
7	.743	.249	.185007
8	.742	.249	.184758
9	.742	.249	.184758
10	.742	.248	.184016
11	.742	.248	.184016
12	.742	.248	.184016
13	.742	.248	.184016
14	.742	.248	.184016
12	.742	.248	.184016
16	.742	.248	.184016
17	.742	.248	.184016
18	.742	.249	.184758
19	.742	.249	.184758
20	.742	.249	.184758
21	.743	.249	.185007
22	.743	.249	.185007
23	.743	.249	.185007
24	.743	.248	.184264
25	.743	.248	.184264
26	.743	.248	.184264
27	.740	.248	.183520
28	.743	.248	.184264
Mean of 29 =			.184402
Maximum			.185256
Minimum			.182778
			.002478 Diff.
Mean of the 2			.184017

No. of Experiment.	DATE.	Area of the section of fracture before trial.	Temperature Fahrenheit.	Breaking weight in the scale.
	1834.			
1	Apl. 19.	.185007	912	96
2	"	.184884	90 ap.	215
3	"	.184016	602	144
4	"	.184016	817	108
5	Apl. 26.	.184007	63	214
6	"	.184512	63	217
7	"	.184007	992	72
8	May. 24,	.184264	81.75	212
9	"	.183892	81.75	216.75
10	"	.184882	81.75	213.25
11	"	.184758	81.75	213.25
12	"	.184016	81.75	213.75
13	"	.184016	81.5	214.5
Mean of 13 =		.184329		

TABLE XXII.

shears one inch wide, filed to the size recorded, marked and gauged at every inch. Specific gravity, 8.8543.

Breaking weight X leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	Point of fracture.	REMARKS.
2880	144	2736	14789	No. 5½	Part in tin from 3 to 6½.
6450	322	6128	33145	" 3½	
4320	216	4104	22302	" 11⅛	Part in metal 9 to 12 inclusive. The temperature recorded is supposed to be a little too low, as a short time elapsed after the fracture, before it was noted.
3240	162	3078	16727	" 17	
6420	321	6099	32966	" 8	
6510	325.5	6184	33515	" 3	
2160	108	2052	11091	" 23	Part in metal from 22 to 24½. As the surface of the copper was not oxidated before trial, this temperature caused some alloying which may have slightly diminished the strength.
6360	318	6042	32790	" 21¾	Probably a little weakened by the preceding high temperature.
6502.5	325.12	6177.38	33592	" 27½	
6397.5	319.87	6077.63	32819	" 20¾	
6397.5	319.87	6077.63	32895	" 18¾	
6412.5	320.62	6091.88	33105	" 16½	
6435	321.75	6113.25	33221	" 15	
					The mean area of the 13 sections of fracture .000073 square inch *less* than the mean area of the 29 measured sections.

TABLE XXIII.

Experiments on copper bar No. 8. Manufactured by John M'Kim, Jr., & Sons, of Baltimore, from South American pig, melted, refined, and rolled into boiler plate, full ¼ inch thick. Cut off with the shears

Marks.	Breadth.	Thickness.	Area of the sections measured before trial.
0	.766	.256	.196096
1	.766	.262	.200692
2	.766	.260	.199160
3	.768	.260	.199680
4	.769	.263	.202247
5	.770	.263	.202510
6	.767	.263	.201721
7	.768	.256	.196608
8	.764	.263	.200932
9	.766	.255	.195330
10	.766	.254	.194564
11	.768	.257	.197376
12	.766	.258	.197628
13	.766	.259	.198394
14	.768	.259	.198912
15	.768	.259	.198912
16	.769	.263	.202247
17	.772	.260	.200720
18	.772	.260	.200720
19	.772	.260	.200720
19½	.770	.260	.200200
20	.759	.258	.195822
20½	.751	.258	.193758
21	.755	.257	.194035
22	.762	.258	.196596
23	.765	.258	.197370
24	.764	.258	.197112
25	.765	.261	.199665
26	.761	.262	.199382
27	.762	.258	.196586
28	.757	.258	.195306
Mean of 31=			.198420
Maximum			.202510
Minimum			.193758
			.008752 Diff.
Mean of the 2=			.198134

No. of the experiment.	DATE.	Area of the section of fracture before trial.	Temperature Fah.	Breaking weight in the scale.
	1833.			
1	Nov. 16.	.202510	212°	225.75
2	"	.201391	65.75	233.
3	"	.199290	65.75	233.
4	Nov. 21.	.197597	212.	226.
5	"	.197284	302.	215.
6	"	.199034	62.	229.
7	"	.197197	62.	233.5
8	"	.201721	64.	235.25
9	"	.197502	60.	238.
10	Nov. 23.	.194569	60.	238.
11	"	.202247	302.	217.75
12	"	.200720	65.	235.75
13	"	.198912	65.	235.75
14	"	.197525	65.	232.
Mean of 14=		.199107		

TABLE XXIII.

1 inch wide, filed to the dimensions recorded, marked and gauged at every inch. Specific gravity 8.9285.

lbs. wt. × leverage.	Friction.	Effective strain.	Strength in lbs. per square inch.	Point of fracture.	REMARKS.
6772.5	338.6	6433.9	31778	No. 5	Part in oil from 2½ to 5½.
6990.	349.5	6640.5	32973	" 3⅔	May have been warmed by the machine.
6990.	349.5	6640.5	33321	" 2¼	
6780.	339.	6441.	32596	" 11⅞	Part in oil from 11 to 14½.
6450.	322.5	6127.5	31059	" 23⅓	Part in oil from 22 to 25.
6870.	343.5	6526.5	32791	" 26⅛	Probably somewhat heated by the machine.
7005.	350.25	6654.75	33749	" 8⅔	The fractured part had been gripped in a former experiment, but showed no weakening from that cause.
7057.5	352.87	6704.63	33237	" 6	
7140.	357.	6783.	34343	" 11½	
7140.	357.	6783.	34862	" 10	Broke with the same weight as the preceding, but with a slow motion.
6532.5	326.62	6205.88	30685	" 16	Part in oil from 15½ to 18½.
7072.5	353.62	6718.88	33474	" 17	
7072.5	353.62	6718.88	33783	" 14	Broke rapidly—weight appeared to be a little too great.
6960.	348.	6612.	33474	" 26⅔	The mean area of the 14 sections of fracture .000701 square inch *greater* than the mean area of the 31 sections measured.

Effect of increased temperature on copper.

The effect of temperature on tenacity, has been hitherto but slightly examined, either for theoretical or practical purposes. The general truth that heat diminishes, and eventually overcomes cohesion, is too well established by daily observation to admit of question.

The temperature of *no tenacity*, is generally supposed to be that at which the fusing point of the given substance is placed, and the point of maximum tenacity ought, upon general principles, to be found at the point where least heat prevails, that is, at the natural zero, or point of *absolute cold*, if such a point exist in nature. Between these two extremes, it might be supposed that the tenacities of different substances, particularly such as are capable of passing immediately from the solid to the liquid state, would be found to obey certain laws. As the total cohesion at the maximum would present to a mechanical agent tending to overcome it, the whole of its resistance, and as, at more elevated temperatures, a part of that tenacity would be overcome by heat, and the rest must be destroyed by the mechanical force, it is evidently a question of experiment, to decide what relation the two forces have to each other at the several temperatures between the two extremes to which we have just alluded. To decide the theoretical question, or, in other words, to deduce, from the experiments, a law which might be expressed in an abstract form corresponding to all the possible phenomena, would require a state of the materials different from that usually found in commerce or employed in the arts. It would also, as we have seen, require a knowledge of that, about which philosophers no less than practical men, are far from being agreed;—namely, the point of absolute cold. As the purposes of this committee did not lead them to investigate the problem in all its *possible* bearings, but only in view of the limits which practice assigns, and with the conditions commonly given to the materials, it will not perhaps, be easy, to construct from the tables a formula in all respects unexceptionable.

The general course of experiments involved the necessity of operating, at the different temperatures, on different bars of copper, and as all the bars are not found to give, even at ordinary temperatures, the same strength, for equal areas of section, it became necessary to deduce from experiments on each bar, at some assumed low temperature, a standard tenacity with which to compare its strength at every other point. The part of this *standard tenacity* which was taken away by the heat at the higher temperatures, becoming known by the experiment, a comparison was furnished for deciding approximately the relation between the temperature given, and the portion of tenacity which it had overcome. It will be found on an inspection of Table XXIV. containing the comparison of these experiments, that on the eight different bars, the whole number of trials which furnished standards of comparison, at ordinary temperatures, was sixty-six, and consequently on an average about eight trials to each bar; while at the elevated temperatures there were made thirty-nine different experiments at nineteen different points on the scale, the greater number of points, however, having but one experiment each.

An inspection of plate IX., where these experiments are represented, will show that at nearly all parts of the scale, within which the trials were made, the strength diminishes more rapidly than the temperature increases, but some of the higher experiments indicate that the conditions of the law are such as to be represented by a curve, having a point of inflection. It will

also be noticed that the three experiments which appear anomalous, and which in the plate are marked with queries, are all found in trials of the same bar of copper, (No. 7,) and that all these might be referred to a curve, varying but little in form from that which we have traced. It is not however *necessary* to suppose that these experiments belong to a different curve, for upon recurring to the table of bar No. 7, (Table XXII,) it will be found that one of the anomalies is satisfactorily accounted for by a delay in taking the temperature after the fracture had occurred, and that one of the others and probably both, were cases of weakening by a slight alloying of the copper by the melted metal through which it passed, in consequence of not having been defended by oxide. The other bars tried at high temperatures were treated with dilute nitric acid, creating a thin film of oxide, which effectually defended the surface, without sensibly diminishing even the smoothness of the bar.

It will be observed that the difference of tenacity, at the *lower temperatures*, for a difference of from 60 to 90 degrees, is scarcely greater than the actual *irregularities* of structure in the metal at common temperatures, and consequently, it was not practicable from these experiments alone to deduce a law which should express the tenacities at all points between the maximum above referred to, and the melting point of the metal. Nor would much confidence probably have been reposed in results thus obtained.

In laying down the results in plate IX, the line *a b* is made to represent the total tenacity of copper at 32°. The horizontal dotted lines express the observed temperatures above 32°, and the vertical ones, the diminutions of tenacity at the respective points.

[TO BE CONTINUED.]

On Calcareous Cements. By JAMES FROST, Civil Engineer.

No. 5.

[Continued from p. 19, of Volume XVIII.]

By some unfortunate accident the following Essay was lost in transmission by the mail, and its non-appearance induced the author to suppose that we had declined its insertion, as not thinking it of sufficient importance; so far, however, from this being the fact, we unhesitatingly say that we not only view the subject itself as one which is surpassed in importance by very few others, but that we are fully assured that the author of these essays adds to competent theoretical knowledge, an extent of practical acquaintance with the manufacture and employment of hydraulic cements but rarely attained; and he may rest assured that any apparent neglect, should it again occur, ought to be attributed to accidental causes, or, to any thing rather than to a low estimate of the real worth of these essays. EDITOR.

In my last essay I stated that whatever substances were found in uncalcined limestone, or carbonate of lime, could not be considered as in a state of chemical combination with the lime. This fact appears to be proved by the lime therein being always found to contain its full equivalent of carbonic acid; and any magnesia, also, which may be found therein, is in like manner saturated with carbonic acid, and is, therefore, not supposed to be in chemical combination with the lime. But it is a fact, worthy of remark, that although the carbonates of lime, and of magnesia, are each

rapidly dissolved, in their separate state, by muriatic acid, the magnesian limestones are acted upon by it with comparative slowness and feebleness. They are, as a class, so distinguished by mineralogists; and this seems to indicate a secondary state of affinities existing between lime and other substances, hitherto wholly unnoticed, and which, in connexion with some other circumstances will be hereafter adverted to in explaining some curious facts.

The other substances most commonly found in limestone, are silex, alumine, and the protoxides of iron and magnesia. The silex as thus found is not only insoluble in muriatic acid, but renders the alumine and metallic oxides partially so, a fact which is also worthy of special observation, because alumine alone is very soluble, and the protoxides, although slowly, are also soluble; nor does the alumine seem to be in chemical combination with the silex, for it is always in the state of an hydrate in clays, and its quantity therein may be estimated by drying the clay for some time in a heat of 212° of Fahrenheit, weighing it, and then heating it to redness for an hour, and reweighing it; as it will then have parted with its water, the weight lost will indicate the quantity, as at 212° the water and alumine in the hydrate appear to be about equal in weight. Alumine is never found in the form of a carbonate, although the reverse of this has been stated in some works. When any one or more of the aforenamed substances are found in sufficient quantity in a state of minute division, and of intimate mixture, either in natural limestones, or in artificial compounds, and subjected to calcination, the calcined mass may prove to be quicklime, slacking with greater or less facility, or a cement incapable of slacking, according to the degree of calcination employed; this is peculiarly the case with compounds of lime and silex. This is a fact of the utmost importance, and yet it is manifest that it is unknown to some persons of great eminence who have treated on cements.

In the Annales de Chimie et de Physique, there is a detailed investigation of the acquired properties of calcined mixtures of gelatinous silex and lime, by that eminent chemist Berthier. From mixtures of two, of three, and of four parts of gelatinous silex, with ten parts of chalk, submitted to calcination, he obtained lime only; yet it will be seen that a cement may be produced from one part only of pulverized silex, with ten parts of chalk, if sufficiently calcined. I communicated this fact, personally, to M. Berthier, in Paris, about seven years since; and about five years ago he published in the Annales, the analysis of a specimen which I gave to him, stating that the cement was used in London, but not giving the source of his information, which I wish he had done, as he scarcely appeared to credit my statement at the time I made it. In his first paper also, he stated that iron was not only useless, but absolutely injurious in cements, whilst in England iron is considered as an essential ingredient in the formation of these substances. We, however, shall find that a cement may be formed by the combination of any two, or more, of the aforenamed substances, but that they each require a peculiar management, and are possessed of very different properties; a point which it is of great importance to understand, as there are some which appear at first the most promising, that are very perishable, whilst others, of much less promise at first, seem destined to be of almost infinite duration.

When the calcination has been sufficient a remarkable change may be perceived in the chemical habits of the combined substances,—the lime no longer slacks, it combines with a smaller quantity of water, or of carbonic

acid, and all the other substances are readily soluble in muriatic, or in nitric acids.

These changes are due to the fusing of the substances in contact with the lime, and probably not to the fusion of the lime itself, for if a hole be formed in chalk, and a piece of London, or fusible, clay, be placed therein and heated in a reverberatory furnace, the clay will be found melted and absorbed, while the chalk retains its form, but is, to some distance surrounding the hole, converted into cement.

The simple calcination of pure silex, in transparent rock crystal, is unattended with the slightest loss or gain in weight, nor is it rendered even slightly soluble in acids; but it suffers great changes in structure, becoming opaque, white, full of fissures, and brittle. Again, when the white silex is procured from the black flints, it is, in all appearance, the same, but the flints lose about two per cent. of water in the operation; they are, therefore, probably hydrates of silex. Again, when the white silex is calcined in contact with the white lime, no weight is gained or lost, by the operation, but the resulting compound is reduced in bulk, and assumes a gray colour; now as silicon is of a dark brown colour, and as no weight is lost in the calcination, the inference seems probable, that, in uniting, the lime has taken oxygen from the silex, and has thereby lessened its affinity for water.

We have strong grounds of confirmation of these views from the analogy exhibited by the calcination of compounds of peroxides of iron and lime; when the calcination is not sufficient to change the red colour of the mass, the lime slacks; if it is sufficient, a loss of weight ensues, equal to the second dose of oxygen in the peroxide; the compound becomes of a greenish yellow colour, and is readily soluble in acids, whilst it is well known that the peroxide is of very difficult solubility therein; when the protoxide of iron is thus calcined, if the mass retains its dark gray colour the lime slacks, if it is changed to a greenish brown a cement results. It seems difficult to explain these appearances without admitting the transference of oxygen to the lime.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

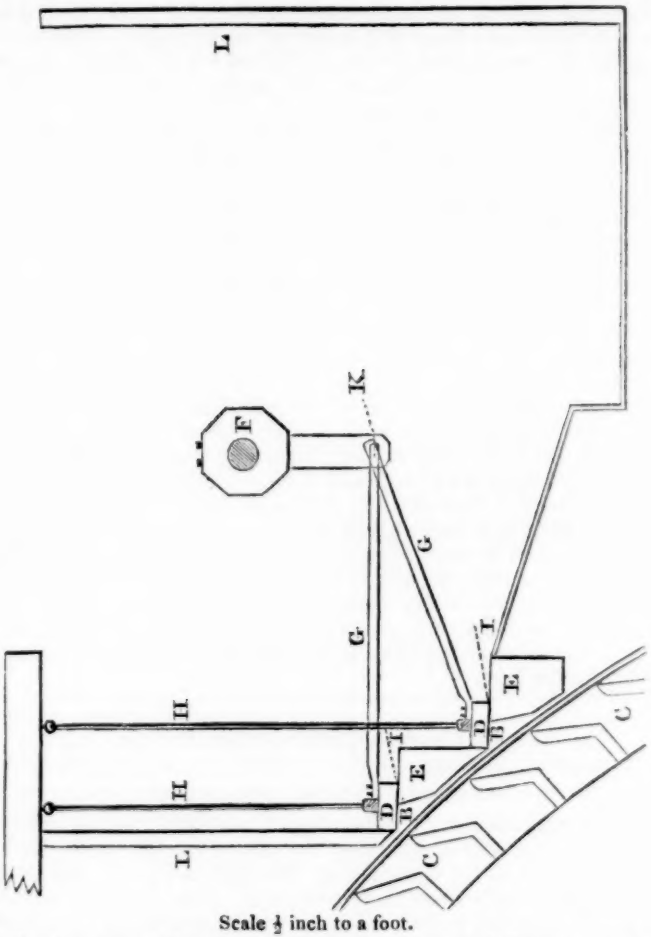
On so suspending the Gates of Water-Wheels, as that they shall be opened and closed with facility and precision.

Mr. Editor,—Others of your readers, probably, besides myself, have experienced a difficulty in regulating the speed of water wheels, on account of the obstruction to the operation of the regulator, by the pressure upon the gates, particularly when any considerable flood of water increases the pressure. I therefore communicate the plan I have adopted, which an experience of more than four years has proved to be an effectual remedy.

Our gates, as I suppose is the general practice, slide horizontally over the opening in the mouth piece. When they are made to fit, as close as is necessary to prevent leakage, there must be considerable friction; so that when the regulator draws upon the gate, it continues to strain, until, by a sudden start, the gate opens or shuts too far, and thus causes the speed continually to vibrate, above or below the regular rate.

In the annexed diagram, L L indicates the sides of the flume. B B are the openings to admit the water to the wheel. C C, a segment of the wheel. D D the gates, which slide upon the mouth pieces E E. F is the gate roll, connected with the regulator. G G, the rods to move the gates. The dotted curve K shows the motion of the lever attached to the gate roll.

This, I believe, is the usual arrangement in the best mills in this part of the country.



Scale ½ inch to a foot.

In order to prevent the drag of the gates, I suspend them, as represented by the rods H H, so that when they are shut, they bear upon the mouth piece as usual, but as soon as they are opened sufficiently to put the mill in operation, this motion being in the direction of the dotted curves I I, they are lifted from the mouth pieces, and hang suspended by the rods H H, so as to relieve them from friction, and the pressure of the water, to such a degree that they swing with perfect ease, according to the motion of the regulator.

Our wheels—York factories—are thirty feet in diameter, and of sufficient power to drive 7500 spindles with 300 looms; and a small regulator, applied in this way, has operated very satisfactorily for several years. Those who have experienced the inconvenience of operating their gates

under a considerable head of water, may perhaps be benefitted by the publication of the above, for which purpose it is at your service.

SAMUEL BATCHELDER.

Saco, Maine, January, 1837.

NEW PATENT LAW.

We have now the pleasure of presenting to the public the Law for the restoration of the Records and Models of the Patent Office, which will be found, also, to contain various provisions tending to secure the rights of bona fide inventors. For whatever there is of good in this law, and we think that there is much that is so, the public are indebted to the indefatigable exertions of the Hon. John Ruggles, of the Senate of the United States, who has devoted himself to this subject with equal zeal and success, from the inception of the bill, to its final signature by the President, at the moment before his term of office expired.

AN ACT,

In addition to the act to promote the progress of science and useful arts.

And be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any person who may be in possession of, or in any way interested in, any patent for an invention, discovery, or improvement, issued prior to the fifteenth day of December, in the year of our Lord one thousand eight hundred and thirty-six; or in an assignment of any patent, or interest therein, executed and recorded prior to the said fifteenth day of December, may, without charge, on presentation or transmission thereof to the Commissioner of Patents, have the same recorded anew in the Patent Office, together with the descriptions, specifications of claim, and drawings annexed or belonging to the same; and it shall be the duty of the Commissioner to cause the same, or any authenticated copy of the original record, specification, or drawing which he may obtain, to be transcribed and copied into books of record to be kept for that purpose; and wherever a drawing was not originally annexed to the patent and referred to in the specification, any drawing produced as a delineation of the invention, being verified by oath in such manner as the Commissioner shall require, may be transmitted and placed on file or copied as aforesaid, together with the certificate of the oath; or such drawings may be made in the office, under the direction of the Commissioner, in conformity with the specification. And it shall be the duty of the Commissioner to take such measures as may be advised and determined by the Board of Commissioners provided for in the fourth section of this act, to obtain the patents, specifications, and copies aforesaid, for the purpose of being so transcribed and recorded. And it shall be the duty of each of the several clerks of the Judicial Courts of the United States, to transmit, as soon as may be, to the Commissioner of the Patent Office, a statement of all the authenticated copies of patents, descriptions, specifications, and drawings of inventions and discoveries made and executed prior to the aforesaid fifteenth day of December, which may be found on the files of his office; and also to make out and transmit to said Commissioner, for record as aforesaid, a certified copy of every such patent, description, specification, or drawing, which shall be specially required by said Commissioner.

SEC. 2. *And be it further enacted*, That copies of such record and drawings, certified by the Commissioner, or, in his absence, by the chief clerk,

shall be prima facie evidence of the particulars of the invention and of the patent granted therefor, in any judicial court of the United States, in all cases where copies of the original record or specification and drawings would be evidence, without proof of the loss of such originals; and no patent issued prior to the aforesaid fifteenth day of December shall, after the first day of June next, be received in evidence in any of the said courts in behalf of the patentee or other person who shall be in possession of the same, unless it shall have been so recorded anew, and a drawing of the invention, if separate from the patent, verified as aforesaid, deposited in the Patent Office; nor shall any written assignment of any such patent, executed and recorded prior to the said fifteenth day of December, be received in evidence in any of the said courts in behalf of the assignee or other person in possession thereof, until it shall have been so recorded anew.

SEC. 3. *And be it further enacted*, That whenever it shall appear to the Commissioner that any patent was destroyed by the burning of the Patent Office building on the aforesaid fifteenth day of December, or was otherwise lost prior thereto, it shall be his duty, on application therefor by the patentee or other person interested therein, to issue a new patent for the same invention or discovery, bearing the date of the original patent, with his cerficate thereon that it was made and issued pursuant to the provisions of the third section of this act, and shall enter the same of record: *Provided, however*, That before such patent shall be issued, the applicant therefor shall deposite in the Patent Office a duplicate, as near as may be, of the original model, drawings, and description, with specification of the invention or discovery, verified by oath, as shall be required by the Commissioner; and such patent and copies of such drawings and descriptions, duly certified, shall be admissible as evidence in any judicial court of the United States, and shall protect the rights of the patentee, his administrators, heirs, and assigns, to the extent only in which they would have been protected by the original patent and specification.

SEC. 4. *And be it further enacted*, That it shall be the duty of the Commissioner to procure a duplicate of such of the models destroyed by fire on the aforesaid fifteenth day of December, as were most valuable and interesting, and whose preservation would be important to the public; and such as would be necessary to facilitate the just discharge of the duties imposed by law on the Commissioner in issuing patents, and to protect the rights of the public and of patentees in patented inventions and improvements: *Provided*, That a duplicate of such models may be obtained at a reasonable expense: *And provided, also*, That the whole amount of expenditure for this purpose shall not exceed the sum of one hundred thousand dollars. And there shall be a temporary board of commissioners, to be composed of the Commissioner of the Patent Office and two other persons to be appointed by the President, whose duty it shall be to consider and determine upon the best and most judicious mode of obtaining models of suitable construction; and, also, to consider and determine what models may be procured in pursuance of, and in accordance with, the provisions and limitations in this section contained. And said commissioners may make and establish all such regulations, terms, and conditions, not inconsistent with law, as in their opinion, may be proper and necessary to carry the provisions of this section into effect, according to its true intent.

SEC. 5. *And be it further enacted*, That, whenever a patent shall be returned for correction and re-issue under the thirteenth section of the act to which this is additional, and the patentee shall desire several patents to

be issued for distinct and separate parts of the thing patented, he shall first pay, in manner and in addition to the sum provided by that act, the sum of thirty dollars for each additional patent so to be issued: *Provided, however*, That no patent made prior to the aforesaid fifteenth day of December, shall be corrected and re-issued until a duplicate of the model and drawing of the thing as originally invented, verified by oath as shall be required by the Commissioner, shall be deposited in the Patent Office. Nor shall any addition of an improvement be made to any patent heretofore granted, nor any new patent be issued for an improvement made in any machine, manufacture, or process, to the original inventor, assignee, or possessor of a patent therefor, nor any disclaimer be admitted to record, until a duplicate model and drawing of the thing originally intended, verified as aforesaid, shall have been deposited in the Patent Office, if the Commissioner shall require the same; nor shall any patent be granted for an invention, improvement, or discovery, the model or drawing of which shall have been lost, until another model and drawing, if required by the Commissioner, shall, in like manner, be deposited in the Patent Office; and in all such cases, as well as in those which may arise under the third section of this act, the question of compensation for such models and drawings, shall be subject to the judgment and decision of the Commissioners provided for in the fourth section, under the same limitations and restrictions, as are therein prescribed.

Sec. 6. *And be it further enacted*, That any patent hereafter to be issued, may be made and issued to the assignee or assignees of the inventor or discoverer, the assignment thereof being first entered of record, and the application therefor being duly made, and the specification duly sworn to by the inventor. And in all cases hereafter, the applicant for a patent shall be held to furnish duplicate drawings, whenever the case admits of drawings, one of which to be deposited in the office, and the other to be annexed to the patent, and considered a part of the specification.

Sec. 7. *And be it further enacted*, That, whenever any patentee shall have, through inadvertence, accident, or mistake, made his specification of claim too broad, claiming more than that of which he was the original or first inventor, some material and substantial part of the thing patented being truly and justly his own, any such patentee, his administrators, executors, and assigns, whether of the whole or of a sectional interest therein, may make disclaimer of such parts of the thing patented, as the disclaimant shall not claim to hold by virtue of the patent or assignment, stating therein the extent of his interest in such patent; which disclaimer shall be in writing, attested by one or more witnesses, and recorded in the Patent Office, on payment by the person disclaiming, in manner as other patent duties are required by law to be paid, of the sum of ten dollars. And such disclaimer shall thereafter be taken and considered as a part of the original specification, to the extent of the interest which shall be possessed in the patent or right secured thereby, by the disclaimant, and by those claiming by or under him subsequent to the record thereof. But no such disclaimer shall affect any action pending at the time of its being filed, except so far as may relate to the question of unreasonable neglect or delay in filing the same.

Sec. 8. *And be it further enacted*, That, whenever application shall be made to the Commissioner for any addition of a newly discovered improvement to be made to an existing patent, or whenever a patent shall be returned for correction and reissue, the specification of claim annexed to every such patent shall be subject to revision and restriction, in the same

manner as are original applications for patents; the Commissioner shall not add any such improvement to the patent in the one case, nor grant the re-issue in the other case, until the applicant shall have entered a disclaimer, or altered his specification of claim in accordance with the decision of the Commissioner; and in all such cases, the applicant if dissatisfied with such decision, shall have the same remedy and be entitled to the benefit of the same privileges and proceedings as are provided by law in the case of original applications for patents.

Sec. 9. *And be it further enacted*, any thing in the fifteenth section of the act to which this is additional to the contrary notwithstanding, That, whenever by mistake, accident, or inadvertence, and without any willful default or intent to defraud or mislead the public, any patentee shall have in his specification claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which he was not the first and original inventor, and shall have no legal or just right to claim the same, in every such case the patent shall be deemed good and valid for so much of the invention or discovery as shall be truly and bona fide his own, provided it shall be a material and substantial part of the thing patented, and be definitely distinguishable from the other parts so claimed without right as aforesaid. And every such patentee, his executors, administrators, and assigns, whether of a whole or a sectional interest therein, shall be entitled to maintain a suit at law or in equity on such patent for any infringement of such part of the invention or discovery as shall be bona fide his own as aforesaid, notwithstanding the specification may embrace more than he shall have any legal right to claim. But, in every such case in which a judgment or verdict shall be rendered for the plaintiff, he shall not be entitled to recover costs against the defendant, unless he shall have entered at the Patent Office, prior to the commencement of the suit, a disclaimer of all that part of the thing patented which was so claimed without right: *Provided, however*, That no person bringing any such suit shall be entitled to the benefits of the provisions contained in this section who shall have unreasonably neglected or delayed to enter at the Patent Office, a disclaimer as aforesaid.

Sec. 10. *And be it further enacted*, That the Commissioner is hereby authorized and empowered to appoint agents in not exceeding twenty of the principal cities or towns in the United States, as may best accommodate the different sections of the country, for the purpose of receiving and forwarding to the Patent Office all such models, specimens of ingredients and manufactures, as shall be intended to be patented or deposited therein, the transportation of the same to be chargeable to the patent fund.

Sec. 11. *And be it further enacted*, That, instead of one examining clerk, as provided by the second section of the act to which this is additional, there shall be appointed, in manner therein provided, two examining clerks, each to receive an annual salary of fifteen hundred dollars; and also an additional copying clerk, at an annual salary of eight hundred dollars. And the Commissioner is also authorized to employ, from time to time, as many temporary clerks as may be necessary to execute the copying and draughting required by the first session of this act, and to examine and compare the records with the originals, who shall receive not exceeding seven cents for every page of one hundred words, and for drawings, and comparison of records with originals, such reasonable compensation as shall be agreed upon or prescribed by the Commissioner.

Sec. 12. *And be it further enacted*, That, whenever the application of

any foreigner for a patent shall be rejected and withdrawn for want of novelty in the invention, pursuant to the seventh section of the act to which this is additional, the certificate thereof of the Commissioner shall be a sufficient warrant to the Treasurer to pay back to such applicant two-thirds of the duty he shall have paid into the Treasury on account of such application.

Sec. 13. *And be it further enacted*, That, in all cases in which an oath is required by this act, or by the act to which this is additional, if the person of whom it is required shall be conscientiously scrupulous of taking an oath, affirmation may be substituted therefor.

Sec. 14. *And be it further enacted*, That all monies paid into the Treasury of the United States for patents and for fees for copies furnished by the Superintendent of the Patent Office prior to the passage of the act to which this is additional, shall be carried to the credit of the patent fund created by said act; and the monies constituting said fund shall be, and the same are hereby, appropriated for the payment of the salaries of the officers and clerks provided for by said act, and all other expenses of the Patent Office, including all the expenditures provided for by this act; and, also, for such other purposes as are or may be hereafter specially provided for by law. And the Commissioner is hereby authorized to draw upon said fund, from time to time, for such sums as shall be necessary to carry into effect the provisions of this act, governed, however, by the several limitations herein contained. And it shall be his duty to lay before Congress, in the month of January, annually, a detailed statement of the expenditures and payments by him made from said fund.

And it shall also be his duty to lay before Congress, in the month of January, annually, a list of all patents which shall have been granted during the preceding year, designating, under proper heads, the subjects of such patents, and furnishing an alphabetical list of the patentees, with their places of residence; and he shall also furnish a list of all patents which shall have become public property during the same period; together with such other information of the state and condition of the Patent Office, as may be useful to Congress or to the public.

Approved, March 3d, 1837.

Physical Science.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

A Mode of Analysing German Silver. By Jas. C. Booth.

As the employment of this interesting compound is daily becoming more general, it becomes a point of some importance to the manufacturer to ascertain with some accuracy the composition of those kinds in the market, which are adjudged to possess superior qualities. For this purpose I have contrived a method of analysing them, which may be successfully practised by any one who possesses a little chemical knowledge. A small piece of about 20 grains is dissolved in nitro-muriatic acid with the assistance of a gentle heat, by which means the metals will be converted into chlorides. If the solution be filtered through a small paper-filter, and a white powder remain after washing with water, it is the chloride of silver, the presence of which metal in the compound is accidental and scarcely appreciable. The acidulated solution is then treated by sulphuretted hydrogen, which separates copper and a little arsenic. The sulphuret of copper is collected

on a filter, treated with nitric acid in a gentle heat, till the sulphur appears whitish, then filtered, brought to boiling, precipitated with caustic potassa, filtered and weighed. 100 parts of this precipitate contains 79.83 of metallic copper. To the solution after filtering off the sulphuret of copper, a little nitric acid is added, and the whole heated in order to convert the protoxide into the peroxide of iron. Muriate of Ammonia is then added to the same and a small excess of ammonia, which precipitates only the peroxide of iron. This may be collected on a filter and weighed, 100 parts of it contain 69.34 of metallic iron. The solution is now to be treated with carbonate of soda and evaporated to dryness; the dry mass is treated with hot water, and the residue washed and dried. This powder, consisting of carbonate of zinc and nickel, is mixed with half its weight of saltpetre and ignited until the whole is nearly dry. It is transferred to a filter after being powdered in a small mortar, and is then washed two or three times with pure, but dilute, nitric acid, which dissolves the oxide of zinc, and leaves the *peroxide* of nickel. To the zinc solution carbonate of soda is added, the whole evaporated to dryness, treated with hot water, and the remainder after being dried and ignited is weighed, 100 parts contain 80.13 metallic zinc. The peroxide of nickel is dissolved in hydro-chloric acid, precipitated by caustic potassa, filtered off and weighed, 100 parts of it contain 78.71 metallic nickel.

The separation of nickel and zinc is ever attended with difficulty and some uncertainty, but it is rendered much more simple by the method which I propose, and which is not more inaccurate than others in use. Before weighing any of the above oxides, it is decidedly preferable to burn the filter after shaking off as much of the substance as possible into a platinum crucible, to add the ashes, and then subtract their weight from that of the oxide.

Franklin Institute.

Report on Little & Elmer's Chronometers.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the Certificates of the rate of Chronometer No. 4, made by Messrs. Little and Elmer, of Bridgeton, New Jersey, REPORT,

That they have examined the certificates of the rate of this chronometer, as follows, viz:

No. 1. Certificate of Wm. H. C. Riggs, dated Philadelphia, Nov. 15th, 1835; giving the error with mean time Greenwich + 47m. 39s., daily rate + 17.5.

No. 2. Certificate of E. Gray, dated Calcutta, June 24th, 1836, giving the error + 1h. 50m. 28s. rate + 17.7. The sea rate for the 222 days intervening having been + 17.0.

No. 3. Certificate of William H. C. Riggs, dated Philadelphia, December 4th, 1836, giving its error + 2h. 38m. 57s., rate + 18.2, rate for the 163 days intervening + 17.7, the rate for the whole period of 385 days having been + 17.4, from which the greatest discrepancy noticed was + 0s.8. Mean of the five rates here give + 17.6, discrepancy from average rate + 0s.2.

The Committee have entire confidence in the correctness of these certificates, and referring to their previous report on the peculiarity of the balance

of these Chronometers, published in the July number of the Journal, are happy to pronounce this to be a decided instance of success on the part of Messrs. Little and Elmer; the performance of this instrument at sea, having been on a par with that of the prime chronometers of English, French and German mechanicians.

In conclusion, the Committee recommend to the Board of Managers to award to Messrs. Little and Elmer the Scott's Legacy Medal and premium of Twenty Dollars, subject to the usual regulations of the Committee. All which is respectfully submitted.

(By order of the Committee.)

WILLIAM HAMILTON, *Actuary.*

Philadelphia, March 9th, 1837.

Progress of Practical and Theoretical Mechanics and Chemistry.

On Cements.

A patent was granted to John Henry Cassell, of Mill-wall, for his invention of a cement or combination of materials applicable to purposes for which cement, stone, brick, or other similar substances, may or can be used.—[Sealed April 19, 1834.]

This invention consists in cementing or combining the materials for making roads, and for constructing docks, water-courses, foundations, and other similar works, by the aid of coal or other mineral tar, wood tar, and resinous matters, or the products of tar, in the manner hereafter described; and thus producing a mass, which may be formed or moulded into any figure, which, when cold, will be exceedingly hard, and be serviceable for the purposes of cement, stone, or brick, in constructing any such like works or buildings, as before mentioned. But in order that this invention may be perfectly understood and carried into effect, it may be necessary to describe the methods used by the Patentee for combining such materials together, and applying them to the aforesaid purposes. A quantity of tar, such as is produced by the distillation of coal, shale, or wood, is first taken, and by further distillation the aqueous parts are separated therefrom, and thus the tar or resinous substance is reduced to the consistency of treacle; this is called the first product, the tar or resinous substance being in a thick and adhesive condition when cold. In order to produce the second product, the distillation is carried on still further, and by this means the essential oil is obtained; and for the third product, the process of distillation is carried on, till the substance becomes so adhesive, that a small portion being removed from the still may be drawn out into threads, and when cold, becomes brittle; and for the fourth product, the distillation is carried on still further, till the substance becomes extremely hard, and will not soften by heat, either of the sun, or any artificial heat. The apparatus or still which is used for this purpose, is similar to that which is called a pitch still, which is well known, and forms no part of this invention, nor does the process of distillation for separating the tar into three products; that is to say, first, tar deprived of the aqueous parts, and reduced to a thick and adhesive condition when cold. Secondly, the essential oil. Thirdly, the adhesive tar, or product thereof, which when cold, is hard; and fourthly, the substance not acted on by the heat of the sun. It may be desirable here to remark, that coal tar is preferred, in consequence of cheapness.

The Patentee then proceeds to describe the combining of these products with other materials, in forming a cement or combination in the making of roads, docks, water-courses, and such like works. We will first describe the method pursued in applying this invention to the making of roads, or in repairing them. Having laid out the road, and made the necessary drains for preventing the lodgment of water below the road, the surface is prepared by beating or rolling, in order to compress the earth, particularly when the surface is composed of loose earth, and, by raking, bring the surface to the required figure, that is, with such slopes as may have been determined upon, and make the same as even as possible. The surface is then saturated with the essential oil (the second product) in thin layers, allowing time for it to subside. The oil put on in this manner will quickly penetrate the ground: the second operation is then commenced, which consists of spreading over the surface of the earth so prepared a thin coating of the first product, perhaps one-fourth of an inch thick, then let the same be ignited, and permit it to burn a short time. Dry sand, or fine dry earth, or slag, or cinder, or a combination of these, should then be sifted on the tar and oil, to the depth of about half an inch, which will instantly put out the flame. The ground should then be rolled, in order to cement the tar and sand together; and, in order to facilitate the operation, it is found desirable to have a frame of iron, or other material, about three feet square, which is successively placed over the surface of the ground, and thus complete portions of the surface at each operation. By this means, it will be evident that a thin cemented layer or surface will be produced on the road. In some instances, one, two, or more layers of this description may be made on the road, depending on the extent of traffic to which it is to be subjected; but it will be desirable to remark, that the essential oil is only used previous to the first layer. Having thus prepared the under surface of the road, the Patentee proceeds to describe in what manner the same is finished; and observes, that the finishing materially depends on the description of materials, which may be readily obtained at the place where the road or other work is being constructed, such as broken granite, flint, slag, gravel, or any other hard material suitable for the surface of a road. It should be observed, that the same should be broken somewhat small, say not larger than three inches, and one-third of the third product should be taken to two-thirds of sand, and boil and mix them together; then pour such mixture over the broken materials to the desired depth, which, running into the space between the stones, forms a very hard and solid mass when it cools. When the said fourth product is in a melted state, any of the materials, such as sand, stone, &c., may be mixed in an open vessel, in the proportion of one-third of the fourth product to three of the stone, sand, &c., by weight, and mix them well together; and when so mixed, the composition is spread over the surface of the road from one to four inches deep, or more if it is thought necessary, the road being prepared as before described; this is then rolled, so that as even a surface as possible will be produced; by which means a hard surface will be formed, which will wear exceedingly well, and produce a cheap and lasting road. Or where it is desired that the upper surface should be formed of larger stones, or other material, such as broken granite, flint, slag, or other substances, of a size such as is generally used in making what are called Macadamized roads, frames or moulds may be used, from twelve to forty-eight inches square, open at top and bottom, like a brick mould; pack in them a number of such broken pieces of material, and then run in a quantity of the fourth product in a melted state, and thus

fill up the interstices between the stones or other materials, making the upper surface as even as possible. These materials, when left in the moulds till they are cold, will be strongly cemented together, and be ready to form the upper surface of a road; they should be put on in the following manner: having prepared the road, as above described, by the essential oil, with the first product, and the sand or fine earth, a coat of the third product of the tar should be spread over to about the thickness of one inch; then, while the third product is warm, cover the road with the moulded materials, placing that part which was uppermost in the act of moulding, on the surface of the road prepared as above, and by rolling or pressing, cause the moulded parts to adhere firmly together; by this means, rather a rough surface will be produced, suitable to the tread of a horse. The first preparation is also used to cover good Macadamised or other roads, which firmly cements every stone into its place, prevents the wheels from ploughing up the roads, the water from softening the sub-strata, and preventing mud and dust from rising. The third product is also used, when in a melted state, to pour between the joints of street pavement, in the manner that grouting is now performed: this will cement every stone together, and so prevent water from getting beneath the stones to the sub-soil, or rising therefrom. If the sub-stratum is of a soft substance, or the street is required to be very durable, the ground is first prepared, as described in the first process; the paving stones are then saturated with essential oil, and the third product is then run between the joints of the stones or bricks that are required for foundations. The resin of wood is used for making stone and cast figures, that are required to be of a yellow colour; sand of the required colour is added, as in the fourth process. In some instances, instead of moulding such larger pieces of flint stone, or other material, sand, or fine earth, is mixed with the fourth product when in a hot and melted state, and the composition is moulded, as above described: such materials being very suitable for foot paths, water-cisterns, pipes, and a variety of other useful purposes.

Having thus described the nature of the invention, as applied to roads, the Patentee proceeds to describe its application to canals, docks, water-courses, and such like works. The earth being excavated, and the slopes of the banks made to the intended figure, the next process is to beat the surface of the earth; and in order to render the same as compact as possible, it is saturated with the essential oil, as before described; then a thin layer of the first product of the tar is run over and ignited; after that, sand, or any other dry earth or material, is sifted over, as above described. Three layers of these cemented materials will be sufficient, when applied to the usual slopes for canals and water-courses, and will offer a compact and close surface to the water; which will protect the banks from the prejudicial washing to which they are otherwise subject, and consequently be of great utility when quick traveling is required, or when the canal boats are propelled by machinery. In forming the embankments of docks or quays requiring steep or perpendicular walls, a much stronger facing is required, depending on the depth of the water they are to support, and also the description of ground behind. The Patentee proceeds to state that a framing of wood is usually constructed to the desired thickness; and having previously made a good base or foundation of a combination of the fourth product of the tar, with broken stones, or other rough hard materials, and sand or earth, he continues melting and mixing quantities of the fourth product of tar with broken stones and sand, in the proportion of about one

of the fourth product to three of the stones and sand, or other material, and successively throws them into the frame, and levels and beats such concrete mixture, till the frame is quite full to the surface of the intended finish of the wall, which is usually made to lay on the surface of the earth. It would be advisable to remark, that between each quantity of the material thus put into the frame, it is found desirable to spread over a thin coat of the first product of the tar, and ignite the same, in order that the surface of the last quantity should be in a melted state, to receive the next quantity of the materials. It will be evident, from the above description, that piles, and also land-ties, may be built in the walls, in order to give additional strength to them; and that where frames or moulds are used, they are washed over with a covering of white-wash or of clay, by which means the composition does not adhere to them.

The Patentee concludes by saying, that having thus described the nature of his invention, and the manner in which the same is performed, he would have it understood that he does not claim any of the materials separately; and it will be evident that the means of carrying the same into effect, may be varied to suit the particular object to which the invention is to be applied: but he would have it understood, that what he claims as his invention, is the cementing or combining the materials for making and mending roads, and for constructing docks, water-courses, water-tanks, pipes, and such like works, by the aid of tar and resinous substances, or the products thereof, as above described. Lon. Jour. Arts and Sciences.

Schools of Art.

It is somewhat remarkable that in a country whose population is so rapidly extending as in these United States, and where the importance of popular education is so sensibly felt by every intelligent and sober minded citizen; in a country too where manufacturing industry is already acknowledged to be one of the chief pillars of national prosperity, that there has been, hitherto, no direct support afforded by any of our State or Municipal governments to the arts of design—including not only sketching, drawing, copying from art and nature, colouring, perspective, &c.; but architecture, geometry, trigonometry, algebra, and all the departments of mathematics, history and geography connected with the application of the arts of design to manufactures, agriculture and commerce. In such Schools, under proper endowment and enlightened management, those departments of physical science which are now deemed to be essential auxiliaries in the progress of the useful arts—mechanical philosophy, chemistry, geology, botany, &c. might constitute a higher and finishing department, and students who have pursued a thorough course of study in such an institution, ought to undergo examination and receive such honorary testimonials as would secure to them that respect and weight of Character in their pursuits which is gained by the diplomas of medical and other colleges. We know of no Institution of this kind in our country that has received any patronage from government, or participated in those public bounties which are beginning to be showered with becoming liberality, on common schools, academies and colleges. The opportunities which our youths enjoy of becoming acquainted with the arts of design and the various cognate sciences, are incomparably more meagre than those of Great Britain; and yet this subject has been judged worthy of an elaborate report by a committee of Parliament, which indulges in terms

of regret and almost of self-crimination at the low state of the Arts of Design, and the dearness of such instruction in England, compared with France, Prussia, and other portions of the Continent. The report speaks in high terms of "the free, open and popular system of instruction (prevalent in France since the days of Colbert,) and the extreme accessibility of their museums, libraries and exhibitions, which have greatly tended to the diffusion of a love of art, as well as of literature, among the poorer classes of the French." It adverts to the immense advantages which the kind of knowledge we are speaking of, confers upon the manufactories of silk and cotton fabrics, upon articles of furniture, upon pottery and glass making, upon architecture, printing, engraving, and other kindred pursuits.

Excepting the Institute in Philadelphia, whence our Journal emanates, in which, by dint of private exertion, a school of drawing is now supported, together with lectures upon some of the most useful and popular sciences, the national academy of design in New York, rather badly sustained we believe, and perhaps an institution somewhat similar in Boston, we know of nothing in the United States which deserves the name of a School of Arts.

The following extracts, from the testimony of Dr. Bowring, M. P. before the committee of Parliament, contains matter, we think, worthy of the notice of our Governors and Legislatures, who, in most parts of the United States, have now the means of dispensing ample funds for the purposes of useful instruction. G.

Abstract of Evidence given before the Committee.

Dr. Bowring examined.—My attention has been called to the subject of the connexion of design with manufactures in various countries, as one of the Commercial Commissioners of the British Government, and it has been naturally a primary object to discover in foreign manufactures the causes of superiority. I have examined in more or less detail the manufactures of the whole of central and southern Europe; but with a special view to the inquiries of the Committee, the state of the fabrics of France is the most interesting; for the superiority of France, where it exists, is almost wholly attributable to the application of art and taste to the various raw materials of her manufacture. If the manufacturing exports of France be examined, it will be found that in those departments of industry in which taste can be introduced into manufacture. the superiority of France is remarkable and undoubted. I will mention an example:—Of the silk manufactures of France, five-sixths of her whole productions are exported; of the silk manufactures of England, probably not more than one-eighth or one-tenth are sent to foreign countries. The reason is found in the superior excellence of French patterns. So in the cotton manufacture, for in those departments of France, Alsace for example, where the arts are most advanced, they are, notwithstanding the higher price of the raw material, notwithstanding the imperfection of their machinery, the absence of sufficient capital and the heavy local taxation, able to export those cotton manufactures which are recommended by beautiful patterns, or are in any way connected with the application of the fine arts to manufactures. It appears to me, that the only way to get over every question of prejudice, and to decide on the real superiority of the manufactures of a country is to go to a third market, to which all countries have access; and if you find in every such market preference is given to certain articles, there can be no doubt that

those articles have in themselves an innate and essential superiority. I mention this, because in this country, for a very long period, an idea existed that it was prejudice, a passion for novelties, a blind preference for foreign articles, and not the substantial fact of superiority which created the demand for certain manufactures imported from other countries. The action of a superior French taste has operated directly on the improvement of many articles, and really, even though remotely, upon the whole extent of our manufactures. Their presence has created a superior school, and has acted upon the English manufactures in the same way that the works of the great masters have acted on the schools of art. The causes of French superiority appear to me to be many and various; probably something is to be attributed to the national character. Their great restlessness and love of change, their *mobilité*, as they term it, constantly creating new objects, and the demand for new objects. I think, too, the circumstances that surround them are very favourable to the study and the love of art; their public collections and museums are every where accessible, and very much visited by the labouring population. Their architecture is very varied, and decidedly progressing. The common beds and furniture of their houses are much more graceful than in this country, and frequently exhibit much tastefulness and variety. The costume of the people in different parts of the country must have struck every observant traveller as presenting, amidst its varied character, such frequent and striking specimens of simple and ornamental dress, as pourtray a widely-extended taste and tact. I think, too, the out-door existence of the people, their more immediate and constant connexion with those specimens of art which exist wherever civilized men are congregated together, has had some influence in the formation of national superiority in this respect. Then, too, it appears to me, that a more immediate and prominently active cause of the artistical character of the French population, is to be found in the popular schools of art, which are now not only widely spread, but their field of action and of study is enlarged from day to day. I have visited the schools of art in several departments. The school which I have seen with the most interest, and studied most in detail, and which on the whole I think has been most influential in improving the character of the manufactures, is the school of art at Lyons. I went through that school only a few weeks ago, and was much struck with the great extension that has been given to its influence and its usefulness since I visited the same school some years since. In France, I think there are about eighty recognised schools of art. The origin of all these institutions in France is to be traced to a conviction, that the application of the principles of art and science to manufacture is the best means of improving that manufacture; and there has been a succession of legislative measures, some of them general, some municipal and local, by which these schools of art have been adapted to the wants of peculiar branches of industry. They are generally public, and open and free. There was a time in which it was difficult to get pupils in some of those departments of study, to which I will afterwards refer. When these schools were first founded, there was little disposition on the part of the labouring classes to avail themselves of their advantages; there was a great deficiency of students, particularly in some of the branches where the inferiority of the French workmen was most generally recognised; for instance, in the schools of ornamental architecture; and generally speaking, thirty, or even twenty years ago, the schools of art languished for want of pupils; but now, in many of the towns where I have made inquiries, there is such a rush of students, that

it is impossible to find instruction for all, and this is particularly the case at Lyons. At the present moment there are 200 students in the Lyonese schools; every class is full, and the candidates for admission are many, far more than can be provided for; in fact, they are filled to overflowing, and the different professors assured me they were quite embarrassed by the number of applicants for admission. Now, till within a few years, the number, I believe, never exceeded 120 to 140. The School of Art of Lyons originated in a decree of Bonaparte, dated, I think, from Warsaw. Its object was to give elementary instruction in art, with a view to the improvement of the silk manufactures of France. But its field of usefulness has widened from time to time, and it is now divided into six principal departments—that of, 1. painting; 2. architecture; 3. ornament, and *mise en carte* (which is the means of communicating to a fabric or to a manufacture any model or drawing upon paper.) There is also, 4. a botanical department; 5. a sculpture department; and, lastly, a department which has been added within the last year or two, that of engraving. The department of painting is divided into three sections; the first is the school of painting, or drawing from the living subject; the second from busts or inanimate nature; and the third is called the class of the principles of painting. That general instruction which exhibits the great principles of art connected with its history and progress. The class of architecture is divided into two departments, the school of composition, and the school of ornament. I mentioned before that this ornamental class had formerly little success; and it appears by the returns, that from 1807 to 1830, there were seldom more than from three to four students. According to the report of the last year, I find that at this moment there is not a class more popular, and that the professors are embarrassed by the overflowing number of candidates. The botanical class is divided into two departments, oil painting and water-colours. A botanical garden is attached to the institution, and perhaps nothing presents more prominently the influence that the great schools of art have had upon the manufactures of France than the general botanical correctness of almost all the patterns which have lately emanated from the Lyonese fabric. The designs are almost invariably made from living plants and flowers. It is impossible almost to give a correct and beautiful representation of the object without that. The class of sculpture has two divisions; that of ordinary and of ornamental sculpture. The class of engraving was lately introduced; and, perhaps, it may interest the Committee to know what are the principal improvements which have taken place in the school during the last three years. A considerable collection of models has been made, a living subject now sits in the school five hours a day. The botanical garden is opened under certain regulations, to the students themselves, for the collection of flowers. A large library has been formed of engravings. They have introduced upon the dead subject a course of what they denominate picturesque anatomy. They have attached to the school a cabinet of natural history, and have lately sent to this and to other countries individuals, who have been charged to collect appropriate specimens; and they have collected, in a cabinet attached to the school, all the works of the students which have obtained prizes, independently of the erection of a very large museum, also connected with the school, which contains specimens of the antique. This museum will be open to the public gratis as soon as it is completed. There is a museum at Lyons open gratuitously to the public. I brought with me from Lyons, as an evidence of the extraordinary progress that their schools of manufacture have made, a work of a professor, which I think will

show a superiority in the art of weaving, of which even this country has little idea. This is the work of the Jacquard loom, and affords an example of the *mise en carte* of a very delicate painting, reproduced on silk by the shuttle. I think the Committee will be convinced that nothing comparable to this in beauty and perfection has been yet produced in this country. [*The witness produced the same for the inspection of the Committee.*] I exhibit this to the Committee as a specimen, showing the state of art as taught in the schools, and to give me an opportunity of stating a fact or two as to the changes of opinion which have taken place in Lyons favourable to manufacturing improvement. Jacquard, the inventor of the beautiful and simple machinery by which the most intricate and complicated patterns are produced by the common shuttle, was more than once exposed to assassination, in consequence of the prejudices of the people against his discovery; he was regarded as a public enemy. Three attempts were made upon his life, and he was obliged for years to hide himself from the vengeance of the labouring population. That machine, by which this stuff was wrought, was broken up in the public place by order and in the presence of the authorities. But Lyons, while resisting all manufacturing improvement, saw her trade decline, and her inhabitants reduced to misery. In the time of her distress Jacquard was again thought of, and the resuscitation of the manufacture of Lyons is solely due to the introduction of the mechanism which had been thus publicly and ignominously destroyed. Jacquard not only lived to see himself reinstated in the affections of his fellow-citizens, but was pensioned by the town of Lyons to the extent of 1,000 crowns yearly; he was decorated with the Legion of Honour; he became the pride and boast of the operative classes; and I venture to say, that among the work-people of Lyons there is not at this moment a name held in any thing like the same esteem and affection as the name of Jacquard. He saw this change before he died, for his death took place only last year. He was accompanied to his grave by the most distinguished persons of his neighbourhood, and by multitudes of the working orders, and his picture now occupies the place of honour in the museum of the School of Art. I mention these circumstances as a remarkable instance and evidence of improved opinion, and of the disposition to consider the contributions of art and science as valuable auxiliaries to the manufacturing interests. I attribute their appreciation of the merits of Jacquard to their advancement in the arts. This very town, which treated his discovery with so much injustice, has lately decreed that a monument shall be erected to his memory. At this moment 10,000 Jacquard looms are at work at Lyons. With reference to the beneficial action of the schools, I believe there are not two opinions. In the last report on the state of the schools it is declared that their influence has been incalculable, and that it has elevated the character of the manufacture in all its departments. The words of the report are:—"If collections of ancient patterns be compared with those which are produced at the present time, the extraordinary distance which separates them will be obvious to every body, and every step will exhibit the progress made in abandoning the mere routine of production, and the beauty and perfection which able artists have thrown upon manufactures. The influence of superior models, the counsels of intelligent professors, and the emulation of zealous students and artisans, will be every where discovered. Already the influence of the school is seen in our streets: our architecture is enriching itself with classical ornaments, and the part which Lyons took and the honours which were done her in the late 'Exposition' at Paris, sufficiently attest that the attentions

which have been given to the Schools of Art have had their influence upon the prosperity and reputation of the town and neighbourhood; peace has indeed called the attention of other countries towards our situation. England, Russia, and Switzerland, are our followers; they are endeavouring to move forward with us in the road of our superiority, and perhaps they are not far behind us. But you must make efforts equal to the wants of the epoch, and give more and greater influence and extent to your exertions." I may add here, that I lately visited the Royal School of Design at Paris, where I found that there are no less than 800 students inscribed, of whom 400 are generally present. There, too, the interest felt and the demand for instruction is greatly increasing, and a number of the students do not exceed the age of nine years, at which they are now admitted to the morning lessons. It is right to mention that the general budget of the State gives assistance to the Schools of Art, and the sum not raised by the State is furnished by the municipal funds. At Paris, the budget of the Minister of the Interior gives 20,000 francs to the Royal School of Design, and the municipality gives 6,000 francs. The course of study lasts for three years, and the students pay five francs for the first year, and ten francs for each of the second and third. The municipal funds in France are devoted to those objects, and to more extensive objects of education in some cases. With reference to Lyons, I should state that, at this moment, a very large educational establishment is in progress, called La Martiniere. A gentleman of the name of Martin died in the East Indies, and left immense wealth to the town of Lyons, directing that it should be applied to the creation and endowment of an establishment for public instruction. It is the intention of the trustees to devote a portion of this establishment specially to the arts and sciences. I ought perhaps to mention that, though so many branches of the fine arts are taught in the Lyonese school, they are all subordinate to the manufacture of silk stuffs, the staple productions of the town and neighbourhood. There is a school also at Rouen, but neither so extensive nor so complete. There are also colleges in the communes in which instruction is given in the arts. It forms part of the education in the primary schools. Previous examination is the test of the admissibility of the scholars into institutions such as that of Lyons; they must be Frenchmen; they are to be Lyonese in preference to the inhabitants of other parts of France; if they are workmen, they are obliged to produce their *livrets*, and I believe also the evidence of French citizenship. I have lately been in Switzerland, where a great deal of attention is being paid to the schools of art. I have before me the programme of the school of art at Geneva; that school has principally for its object instruction in those branches of art which can be applied to the manufacture of metals, particularly with reference to watch making and jewellery. It is under the protection of the Government, and students are admitted at the age of fourteen, after examination. The course of study lasts three years; in the first year they are taught arithmetic, and the drawing of machines, with the use of the rule, the square, the compass, and other mathematical instruments. In the second year, algebra and plain geometry, the manufacture of machinery, the elements of physical and mechanical science. In the third year, trigonometry, statics, solid and spherical geometry, the manufacture of more complicated machinery, inorganic and organic chemistry, hydrostatics and hydrodynamics. Switzerland is at this moment the seat of the most extensive production of delicate mechanical works. In the Jura mountains, in the French part of the Canton of Berne, and at Geneva, almost all the

watches, musical boxes, &c. which supply the Continent of Europe and the Western and Oriental world, are manufactured; and the extent to which the knowledge of the mechanical arts is diffused among that population, whose habits are partly agricultural and partly manufacturing, but altogether domestic, is very striking. I imagine that the average rate of wages for manufacturing labour in those districts is higher than in any part of the European world; and the effect of their great knowledge, industry and aptitude has been such, that more than half the population have become proprietors of land. A man can scarcely be found who is not able to read and write, and who is not a practical master of that mechanical art with which his trade is particularly connected; and yet I found amongst all those watch-makers one of the best evidences of knowledge, namely, a wish to know more, the expression of a great desire that further means should be taken to communicate instruction in yet higher branches of art and science; and I will mention a fact of the influence of their superiority, even in remote regions —that I found the Jura mountains had been lately visited by a Chinese, who had come all the way from Canton, and had studied there three years among the watchmakers, in order that he might set up trade in China. Such is their superiority, that they carry on a large trade with the remotest regions, and I believe that superiority to be mainly due to the great diffusion among them of the practical science of mechanics. I think there are eight or nine professors in the Ecole Industrielle of Geneva; but there is also a special school of watch-making, for the instruction of those who mean to pursue that particular branch of industry. In the school at Geneva, five francs are paid for the first year, and ten for the second and third, and the deficit is made up by Government funds. Lond. Mech. Mag.

On the Process of Carbonization, or Manufacture of Charcoal, at Goersdorf, in Saxony.

It having been suggested by M. Boult that a superior charcoal might be produced by filling the interstices of the pile with small charcoal, the refuse of former burnings, an experiment was made, which, after being several times repeated, gave the following results: 1st, an increase of produce, amounting to not less than four per cent. above that yielded by the ordinary process; 2nd, a much smaller quantity of dust and small coal; 3rd, scarcely any smoke; 4th, charcoal of a very equal and superior quality.

A pile prepared for carbonization at Goersdorf contained in general about thirty *schragen* (318 cubic yards) of pine trees split in quarters, which yielded, including the small coal, from eighty-nine to ninety-two per cent. in bulk of charcoal. It was considered desirable to ascertain, whether by increasing the size of the pile, a more considerable product would be obtained. A pile containing forty-nine schragen (about 520 cubic yards,) of cleft pine wood, gave in an experiment, during which the weather proved favourable, 89.94 per cent, of charcoal (including the small,) very sonorous, and of very good quality. A second trial of 69½ schragen (740 cubic yards,) of similar wood produced only 87.98 per cent., but the weather in this instance was unfavourable.

This experiment was repeated with seventy-one schragen (750 cubic yards,) the weather continuing fine throughout the process; the produce amounted to 94.87 per cent.; equal in quality to the former results. The average results of the adoption of this process at Goersdorf, will appear

from the following table of the produce, from the commencement to the date of the latest improvements.

	Produce per cent.		Total produce per cent.
	Large.	Small.	
1821	74.94	3.91	78.85
1822	76.24	4.76	81.—
1823	76.44	5.25	81.69
1824	77.95	4.09	82.04
1825	86.31	4.35	90.66
1826	86.31	3.62	89.93
1827	87.53	4.20	91.73

The increase observable in the produce of 1825, is to be attributed, principally to the care with which the operations were conducted; but it must be also remarked, that the removal of the pipe for collecting the acid formed in the process of carbonization, may also have contributed beneficially to the results. M. Karsten in his *Voyage Metallurgique*, states, that in Carinthia, the carbonization of pine wood is performed in large stacks, containing 20,000 cubic feet, and without the trees being previously split, yet the produce in bulk is computed at from seventy-one to eighty-six per cent. It is obvious, that there exists no analogy between these results and those obtained from the brushwood and billets of oak, beach, &c., by the common process of carbonization, which seldom yields more than from thirty-five to forty-five per cent.; it is, therefore, only necessary to call public attention to the fact, and it may naturally be expected that, in the present state of practical science, a subject of so much importance in metallurgy will be duly investigated. Lond. Quar. Mining Review.

Memoir on the Calcination of Coke.

Abridged from the Report, by Messrs. Perdonnet and Leon Coste, in the Annales des Mines.

Coke is obtained in England by two distinct processes; in the open air, and by means of ovens constructed for the purpose. The former is the method usually adopted, the latter being applied almost exclusively to the small coal or slack. In the vicinity of Dudley, in Staffordshire, all the coke is made in the open air; the process consists in forming a small conical chimney, with bricks placed in such a manner as to leave spaces between them, these openings are larger in the lower than in the upper courses, the usual height is about four feet six inches, surmounted by a cylinder of one foot. The coal is then disposed around the chimney, the largest lumps being placed first to form the base of a cone, after which more is thrown on the heap, until the top is above the level of the brick work; the whole surface is then covered with slack, with the exception of the lowest part of the heap, to about one foot high, the fire is then lighted in the chimney, at a certain period of the operation the remaining part is also covered with slack, and when the carbonization is judged to be complete the fire is extinguised, by throwing on a sufficient quantity of water and dispersing the materials of the heap.

The dimensions of the coke heaps vary considerably, they are most com-

monly fourteen or sixteen feet in diameter, and contain about twelve ton of coals. From the time of lighting the pile the operation is completed in seven days, three for the calcination and four for the extinction and subsequent cooling of the mass.

It would appear that a method so simple as this would be invariable in the results, nevertheless the contrary is the fact, much depending on the attention and judgment of the burner or superintendant. A ton of coal usually yields twelve cwt. of coke, or sixty per cent. sometimes ten cwt. or fifty per cent. from the same materials. In South Wales both methods are practiced, but the coke is not calcined with so much attention as in Staffordshire, the process differs in the heap being made in the form of a long bank four to six feet in breadth, and about three feet high, the large coals in the middle, and the fire being lighted either at one end or at several parts of the heap. At Pontypool and Abergaveny the coke is calcined in the open air; the coal in some parts of this district bears a resemblance to charcoal; in converting it into coke great care is taken to preserve this entire, the operation is completed in five days. In the neighbourhood of Merthyr Tidvill the process is conducted in the open air, and although very little care seems to be given to its progress, yet a considerable quantity of coke is produced, the coal being generally dry and giving but little smoke. At Plymouth works six tons of coal yield five tons of coke; at Dowlay 720 lbs. of coal yield from 450 to 500 lbs. of coke; at Pen-y-Darran the operation lasts only three days, the increase in bulk being also very considerable, three tons of coal producing twelve barrows of coke, each containing seventeen cubic feet, or above one fourth part more than previous to calcination.

At Neath Abbey the carbonization is more rapid than in any other place, it being finished in nine hours, producing rather less than sixty per cent. of coke. In Scotland, calcination in the open air is generally adopted; formerly the heaps were burned without much attention being paid to their progress, but the Staffordshire mode has been used latterly with great advantage, the heaps consisting of eighteen tons of coal, well covered with slack, kept burning three or four days, and four or five days more being allowed for the cooling of the mass, the loss in weight is about fifty per cent.; the old method occupied only five days, but the loss amounted to from sixty to sixty-six per cent. The coke is of very unequal quality, some parts being very heavy and others light and porous. In Yorkshire the coal is arranged in long banks, six feet wide by two and a half high, with square vertical chimneys, eight or nine inches in diameter, formed with large coals, at about the distance of six feet from each other throughout the length; the loss is about fifty per cent. in weight.

Calcination in ovens is considered to produce a heavier coke than the open calcination; the process varies but little, being in all cases performed in ovens of a circular or oval form, with a low arch surmounted with a small chimney, the furnace has two doors or openings opposite to each other, sliding in a groove and raised by a lever, they are usually of cast iron, the dimension of the furnace about twelve feet by six; height of the arch in the centre five feet, at the door twenty-one inches; the chimney rises three feet externally and about nine inches in diameter. At Neath Abbey the furnaces are smaller; the chimney is eighteen inches externally, and only one door, but in this case a hole is made in the opposite side to facilitate the clearing out of the coke. From the small coal carbonized in this manner the produce is about sixty per cent., while the same quantity of coal in the

open air yields but fifty per cent., the coke from the furnace being so much more dense. At Swansea, by the same process, the produce is about fifty-four per cent.

In the vicinity of Glasgow a circular oven with one door is in use, the diameter is nine feet, height of the arch six feet. The coke is drawn out every twenty-four hours; the ordinary charge, one ton and a half of coal, rising about two and a half feet in the oven, the loss is from fifty to sixty per cent. On Saturdays the charge is increased to two tons, and is not withdrawn until the Monday. At the Lymington works, near Newcastle-upon-Tyne, all the coke is made in ovens, the usual charge is one chaldron of about two and a half tons, the operation lasts forty-eight hours, and the average loss thirty-nine per cent. The coke is screened to the diameter of about one inch, for smelting in the high furnace, the smaller portion being employed in roasting the ores. At Bradford, in Yorkshire, the method is similar to Newcastle, but the furnaces are smaller, the charge being only about one ton, the loss is about forty per cent. It is difficult to decide to which process a preference ought to be given, the loss is less in the ovens, but they require more space, more attendants, and more expense, while the open carbonization is considered to yield coke better adapted for smelting in the high furnace. Ibid.

On the Calcination of Ores.

A most simple method for effecting this process is practised at the Iron works in Staffordshire, as well as at some of those in Scotland and Wales. It consists in spreading the ironstone intended for calcination over a bed of coal about a foot in thickness, adding occasionally a layer of small coal, until a heap is raised about eight or ten feet in height, and fourteen or fifteen in diameter; the fire is then lighted, and the operation left to itself without any further attention. The open fires vary, however, in their form. Another, and more economical mode is used in South Wales, by which the refuse coal and coke are consumed in ovens or kilns, constructed for the purpose.

The form of the interior is, usually, a reversed cone or pyramid; those which approach to an oval being also held in much esteem. The operation is easily conducted. The oven, or kiln, being first charged with coal and ironstone, but not entirely filling it, when the fire begins to reach the upper part, small coal is thrown on alternately with the ores, until the kiln is filled. The lower part is then drawn out and left to cool, as in lime burning; the kiln is recharged, and the process continued indefinitely.

In Wales it is generally contrived to erect the blast furnaces on the side of a hill, and the calcining ovens are built on a terrace surrounding it, to the height of the furnace mouth: the time for the operation is regulated so as to keep a supply only to the quantity required for smelting. At Newcastle-on-Tyne a similar method is practised, but the fuel consists of small coke.

At Bradford the ovens are rectangular, and about twenty-five feet in depth, fourteen long, and five wide, in the upper part; towards the middle it takes the form of a truncated pyramid, whose base is about twenty inches diameter: small coke is used here also: at other works in the same vicinity the ovens are of a similar shape to the furnaces, and about fifteen feet in height. These dimensions are, however, exceedingly variable, both in different counties, and some times in the same establishment.

At Pouldice, in Cornwall, the tin ores are roasted, to facilitate the subsequent separation by washing. The furnaces for this purpose have a fire place about one foot by four feet, on the same level as the part destined for the ores, and only separated from it by a course of bricks placed flat; the furnace bed is about nine feet six inches by eight feet; the height of the roof one foot; its course nearly horizontal. In the front of the arch, near the door, is a vent, which, after rising vertically, takes a course nearly horizontal, and discharges itself at the distance of a quarter of a mile into a large chimney, the upper part is formed of flat stones, which are easily removed for the purpose of clearing out the arsenic accumulated on its sides, which is sold for 10s. per ton: on the outside of the furnace is, also, a projecting or forge chimney, rising about fifteen feet. Similar precautions, favourable to the health of the workmen, are in use in all the tin works throughout England, which have not yet been introduced into Germany. The charge of this furnace is six cwt., requiring $1\frac{1}{2}$ bushels of charcoal to each roasting; this is, however variable, as well as the duration of the process, according to the nature of the mineral acted upon. Ibid.

Notice of Carburet of Potassium, and of a New Gaseous Bi-Carburet of Hydrogen. By Edmund Davy, Esq., Professor of Chemistry to the Royal Dublin Society.

(*Communicated to the British Association, 26th August,* 1836.)

In January last, the author made different experiments to obtain the metal of potash on a large scale, by exposing to a high temperature, in an iron bottle, a mixture of previously ignited tartar and charcoal powder, in proportions of the latter varying from about $\frac{1}{10}$th to $\frac{1}{15}$th of the whole mass.

In one experiment, a substance was obtained of a dark gray color, rather soft to the knife, though adhering with tenacity to the iron, and inclining to a granular structure. This substance, when put into water, decomposes it with great facility, carbonaceous matter is disengaged, and gas copiously evolved, with occasional inflammations on the surface, as is commonly the case with potassium under similar circumstances. The gas, when examined, was found to consist of hydrogen, and a new bi-carburet of hydrogen, (noticed in a subsequent part of this communication,) in nearly equal volumes. The author regards the substance in question as a mixture of potassium and carburet of potassium; the former, by its action on water furnishing the hydrogen, the latter, the new gas. In collecting gas from the substance, by the action of water over mercury, a novel and interesting case of combustion was observed. A little of the substance being placed in a tube filled with mercury, on letting up a few drops of water, gas was copiously disengaged, and as the mercury descended along the tube, small portions of the substance became ignited, exhibiting the appearance of bright sparks of fire in continued succession.

In another experiment with the iron bottle, the author procured no potassium, but a small quantity of a substance partly in powder, and partly in small lumps, of a dense black color. This substance the author regards as carburet of potassium. It exhibits no appearance of crystalization to the naked eye; but when viewed with a glass of high magnifying power, the author thinks he has observed congeries of exceedingly minute four-sided prisms, truncated at their solid angles. When the carburet is exposed to

the air, it soon undergoes changes, oxygen and water appear to be absorbed, and caustic potash and carbon remain.

When the carburet is put into water, both substances are decomposed, one portion of the carbon unites with the hydrogen of the water to form the new bi-carburet of hydrogen, which is the only gaseous product, the remainder being disengaged, whilst the oxygen of the water and the potassium form potash.

Alcohol and turpentine act feebly on the carburet, acids strongly.

The carburet undergoes partial decomposition at a dull red heat in close vessels, potassium slowly rises from it, whilst the carbon remains of a deep and bright black color.

The author regards the pure carburet as a binary compound of one proportion of carbon and one of potassium.

New Bi-carburet of Hydrogen.

This gas was obtained by the action of carburet of potassium on water. It is highly inflammable, and when kindled in contact with air, burns with a bright flame, apparently denser and of greater splendor than even olefiant gas. If the supply of air is limited, the combustion of the gas is accompanied with a copious deposition of carbon. When the new gas is brought in contact with chlorine gas instant explosion takes place, accompanied by a large red flame, and the deposition of much carbon, and these effects readily take place in the dark, and are, of course, quite independent of the action of the sun's rays or of light. The new gas may be kept over mercury for an indefinite time without undergoing any apparent change; but it is slowly absorbed by water. Recently boiled distilled water, when agitated in contact with the new gas, absorbs about its own volume of it; but, on heating the aqueous solution, the gas is evolved apparently unaltered. The gas is absorbed to a certain extent by, and blackens, sulphuric acid.

The new gas detonates powerfully with oxygen, especially when the latter forms three-fourths or more of the mixture, and the only products appear to be water and carbonic acid gas. It requires for its complete combustion 2½ volumes of oxygen gas, two volumes of which are converted into carbonic acid gas, and the remaining half volume into water. From the author's analysis by different methods, the new gas appears to be composed of one volume of hydrogen and two volumes of the vapour of carbon condensed into one volume. Its density is therefore less than that of olefiant gas by the weight of a volume of hydrogen equal to that of its own bulk. It is, in fact, a bi-carburet of hydrogen composed of two proportions of carbon and one of hydrogen, and may be represented by the formula $C^2 + H$, or $2C + H$; and its constitution seems to differ from that of any other known gas.

From the brilliancy with which the new gas burns in contact with the atmosphere, the author thinks it is admirably adapted for producing artificial light, if it can be procured at a cheap rate. Rec. Gen. Science.

Composition of Atmospheric Air.

M. T. de Saussure has taken advantage of the property which small shot possesses of absorbing oxygen when moistened and agitated with atmospheric air at common temperatures, to analyze common air. He employed a matrass possessing a capacity of from 150 to 250 centi-metres cubes closed hermetically with a metallic stopper, which is fastened with screws to a firm

socket at the end of the neck of the matrass. The lead shot ought to contain 80 to 100 shots to the gramme, (15.438 grs.) Its weight is nearly the fifth of that of the water which the matrass contains. The water for moistening the shot should be equal to the seventeenth of its weight. A larger or smaller quantity retards the oxidation. Three hours of constant agitation are sufficient to deprive the air of its oxygen. Saussure measures the quantity of oxygen absorbed, by the weight of the water which the atmospheric pressure causes to enter the flask. He affirms, that the lead takes up all the oxygen from the air which undergoes a diminution of volume of 21.05; but as lead absorbs carbonic acid also, amounting, in his experiments, to .0004; it follows, that the quantity of oxygen in the atmosphere is 21.01 per cent. Gay Lussac has suggested another eudiometer, viz., a plate of copper moistened with sulphuric, muriatic or acetic acids.* Ibid.

Analysis of Iron Ores.

Berzelius states the following to be a rapid mode of analyzing these ores. He boils them with chloride of copper slightly acidulated with muriatic acid, then on boiling the residue with carbonate of soda, washing the result, drying and weighing, its weight indicates that of the carbon.† Ibid.

Inferiority of English to China Ink.

The directors of the Bengal bank lately refused payment for a number of bank notes, in consequence of their containing no signature. It appeared that they belonged to a Hindoo, who had kept them in a copper box.—He asserted that they originally possessed the signatures of the director, comptroller, cashier, &c., but that they had been effaced. The notes on which the signatures had been written with China ink remained uneffaced, but all the writing with English ink had completely disappeared. Mr. Princep, in order to determine the question, placed a paper covered with writing in English ink between two plates of copper. After a short space of time he found that the copper had decomposed the ink, and that the writing was completely effaced. He concluded that the account of the Hindoo was correct, and that the bank ought not to refuse payment.‡ Ibid.

Progress of Civil Engineering.

On the Locks commonly used for River and Canal Navigation. By Mr. W. A. Provis, M. Inst. C. E.

1st. Simple Dam Locks.

The earliest approximation to what is now known by the name of lock, consisted of a simple dam formed across the bed of a river, so as to raise the water to such height as to allow vessels to float along it. Where the river had a considerable fall with a strong current, it was necessary to have these dams at short distances from each other, otherwise the requisite

* Rec. Gen. Science, from Ann. de Chim. lxii. 219.
† L'Institut, 170. ‡ Asiat. Society Journal, and L'Institut, 182, 368.

depth of water could not be obtained. As the whole space between two of these dams was, in fact, the lock, it was necessary in passing from one level to another, to run down the water, for the whole of that distance, thereby causing considerable delay, and a waste of water that would now be considered a serious evil. In China these dams are very common; they have also been used on the continent of Europe, and what is not a little extraordinary, are at this very day in use in our own country; my brother having given me a description of one of these which he saw on the river Ouse, near Tempsford, in Bedfordshire, I here insert it.

"The river is somewhat contracted in its breadth by a wall on each bank, between these two, a third, or middle wall, is built, with cutwater ends.—At the middle of each of the passages formed by these walls, a sill is extended across the bottom of the channel, and pile planks are driven along its upper side, with the necessary sheeting to prevent the water getting under it. On one of the side walls a beam similar to the balance of a common canal lock gate is placed, which turning horizontally upon an axis, one end is made to abut against a projecting piece of timber which is fixed in the middle wall; this beam and the before mentioned sill form the top and bottom of a frame, on the upper side of which a row of verticle planks is placed, one at a time, so as to form the working dam; the other space has a piece of timber fixed at the top of its two side walls, corresponding with the sill below, and vertical planks are placed between these in the same manner as at the other opening, but as vessels are not intended to pass through more than one of the openings, the upper beam in the other is fixed. The use of this second space or opening is to allow the water to be run off more expeditiously, particularly during floods. In going up the stream, a vessel passes the place where the temporary dam is to be formed, and then the movable or balance beam is swung round, the vertical planks put down, and the water thereby completely stopped till it rises to such a height as to run over the top of the dam; before this takes place, the vessel has sufficient water, and she proceeds on her voyage to the next dam above; these dams are kept open when there is no vessel near, and at all other times when there is sufficient water for navigation without penning it up."

It may appear, at first, that it would be more advisable to have a complete gate similar to those now generally used on canal locks, but a gate would be attended with these inconveniencies; that the water could not be run out in so short a time by its paddles as it can when the whole space which the gate would occupy is available, and also the difficulty of opening against a rapid stream a gate of the required size. Though this principle of damming up the water was a valuable improvement in our river navigation at the time it was introduced, yet as it is only applicable when water is abundant, and must at this time be considered a very rude mode of passing from one level to another, it requires no argument to shew that it must soon give way to the adoption of our modern locks.

2*d*. *Lock with a double set of Gates, but no Chamber Walls.*

The evils attendant on the dams just described were in a great measure removed by the introduction of double sets of gates or sluices, the upper set being constructed so near to the lower, as only to leave room enough for the vessel or vessels to float between them. Framed gates were also used instead of separate beams and planks, because the space to be emptied or filled was so small, that a very short time was required to pass the water; and there was no stream of sufficient strength to prevent their being easily

opened. Where these locks are intended for rivers, it is usual to make a side cut or artificial canal for the purposes of the navigation, and to leave the river course for the passage of the surplus water. A quick bend of the river is generally chosen for one of these cuts, and to keep the water in the upper part of the river to a sufficient height for navigation, a dam or weir is made across the old river course, at or below the point where the artificial cut quits it.

The lock is then built at the most convenient part of the cut, and its fall made equal to the difference in the levels of the water at the top and at the bottom of the dam or weir.

When a vessel is going up the river, she floats along the cut, and passes between the lower gates into the lock, the lower gates are then closed, and the valves or paddles of the upper gates being opened, the water flows into the lock, and rises to the level of the upper part of the river; the upper gates are then opened, and the vessel floats out of the lock. Of course the reverse of this operation would conduct a vessel down the river.

It will be obvious to every one, that the sides of these locks must rise above the level of the higher part of the river, otherwise the water would flow over and injure them. The gates should also rise above the highest water's surface, or the water would flow over their tops and probably into the passing vessel, so as to endanger its safety or damage its cargo. It has been common to make the gates no higher than the water's surface, but the before mentioned inconveniencies show the necessity of making them higher, and of constructing the dam or weir of sufficient breadth to take off with facility all the surplus water.

The abutments for the gates have been made of timber, brickwork and masonry, but when the double set of gates was first introduced, it was usual to leave the space between the upper and lower gates unprotected by either timber or any kind of building. Of course the agitation of the water in the lock was constantly washing away the earthen banks, thereby causing a risk of their being broken down by such continued weakening; and by enlarging the space between the two sets of gates, it occasioned a loss of time in emptying and filling, as well as a waste of water.

3d. Lock with a double set of Gates, and the sides of the chamber secured by timber.

To check the mischievous tendency of leaving the chamber unprotected, the side banks of many old locks have been in part secured by driving a row of piles along the base of each slope, and fixing planks at the back of them, so as to form a wooden wall for about half the height of the lock; but there is sometimes a risk in trying this experiment, for the space between the two sets of gates being frequently lined or covered with puddle, resting on a porous sub-stratum, the water often escapes by the sides of the piles, and causes not only leakage but a danger of blowing up the lock. Examples of this sort of lock may be seen on the river Lea navigation.

4th. Common modern Canal Lock.

It was not until the construction of artificial canals became very general that locks were brought to any thing like perfection, for the difficulty of procuring sufficient supplies of water had been but partially felt when our inland navigation was confined to a few of the principal rivers.

When canals had spread themselves in various directions over the country, and water became so scarce and valuable as to be the cause of much

litigation and expense, it was necessary to be careful of every resource, and to use it with the strictest economy. For this purpose, the space between the upper and lower gates was contracted to such a breadth as only to leave room enough for the vessel, and the bottom and sides were constructed of brickwork or masonry, instead of sloping banks of earth. By these means the superficial area of the lock was reduced to very little more than that of the vessel, and consequently was as small as it could be made.

The difference of altitude between the upper and lower levels, where the locks are constructed, varies according to local circumstances. Where the ground is longitudinally steep and water plentiful, the locks are generally made of greater lift or fall than where the ground is comparatively flat and water scarce. It is evident that, where the superficial area of locks is the same, one having a rise of 12 feet would require twice the quantity of water to fill it that would be requisite for one of 6 feet. Having many locks, however, of small lifts instead of a few of greater, increases the expense as well as the time for passing them.

For narrow canals these locks are generally made about 80 feet long, and 7½ to 8 feet wide in the chamber. On the Caledonian canal they are 180 feet long, 40 feet wide and 30 feet deep. Locks are also constructed of every intermediate size.

Lock gates have till lately been made of timber; but in consequence of the difficulty of procuring it of sufficient size for those on the Caledonian canal, cast iron was partially adopted for the heads, heels, and ribs. Iron gates, cast in one piece, have been used on the Ellesmere canal, as well as others with cast iron framing and timber planking.

Whether constructed in a single leaf, or a pair of leaves, the gates of locks are usually made to turn horizontally upon a pivot at the bottom of the heel; but there is a singular exception at the locks on the Shrewsbury canal, where, at each end of the lock, a single gate is made to rise and fall vertically, in grooves in the side walls. A pulley is fixed on its axis about 12 feet above the lock, over this a chain is passed, one end of which is fixed to the top of the gate, and the other to a weight, by which the gate is so nearly balanced as to allow of its being worked up and down by one man. On entering or quitting, the boats pass under these gates.

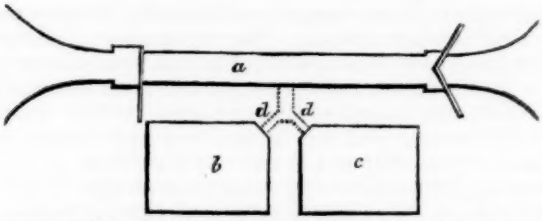
I am not aware of any lock in England of greater rise than 18 feet, but Tatham in his work on canals, (p. 164,) mentions one of 20 feet rise, built in 1643, by Dubie, between Ypres and Furnes, to connect the canals which bear those names. There are two pair of upper gates to this lock to guard against accidents.

On the Languedoc canal there is a celebrated circular lock, which has had more credit bestowed upon it than it deserves. The fact is, it is nothing more than a circular basin, into which three canals of different levels descend by common locks.

Various modifications of this principle have from time to time been adopted either to save water, time, or expense.

5th. Locks with side ponds.

When water is scarce, it is common to construct side ponds, by which a considerable portion (in general one half) is saved. The usual number of these ponds is two, for it has been determined by experience, that when a greater number have been made use of, the loss occasioned by leakage and evaporation has sometimes been more than equal to the additional quantity of water retained.



In the accompanying sketch, *a* is a common lock, *b* and *c* two side ponds, (each equal to the area of the lock,) *d d* two culverts with paddles, each communicating with the lock and one of the side ponds. Supposing the lock to fall eight feet, the bottom of the pond *b* will be four feet, and that of *c* six feet below the surface of the lock when full. If a vessel is to descend, it enters the lock when full, and the gates being closed, the paddles of the side pond *b* are opened, and the water flows into it till the level of the water in the lock is lowered, and that in the side pond raised, till they are the same, which will be when the water in the lock has sunk two feet; the paddles of the side pond *b* are then closed, and those of *c* opened; a similar operation then goes on till the water in the lock has sunk two feet more, when the paddles of *c* are also closed, and the remaining four feet of water in the lock is run into the lower level of the canal, through the paddles in the lock gates. When the lock is to be filled, the water in *c* is first run into the lock, which raises its surface two feet, the water in *b* is next run into it, which raises it another two feet, making together half a lock full, the upper half is then run down from the higher level of the canal.

6th. Locks for the transit of vessels of different sizes.

Where vessels of different sizes have to pass the same locks, three pairs of gates are sometimes placed instead of two,—the distance between the upper and lower pairs being sufficient to admit the largest vessels, and that between the upper and middle pairs being adapted to the smaller class. By this contrivance, when a small vessel is to be passed through, the lowest pair of gates is not used, and when a large vessel goes through, the middle pair of gates is not worked. Thus, it is evident, that the quantity of water contained between the middle and lower pair of gates is saved when a small vessel passes, compared with what would be required were the middle set of gates omitted.

7th. Parallel double transit Locks.

But where the transit is great, much time and water may be saved by a double transit lock, which is, two locks placed close to, and parallel with, each other, with a communication between them, which can be opened or cut off at pleasure, by valves or paddles.

As one of these locks is kept full and the other empty, a vessel in descending floats into the full one, the upper gates are then closed, and the water is run, by means of a connecting culvert, into the empty lock, (the gates of which were previously closed,) till the water in the two locks is on the same level, which will be when each is half full; the connecting paddles are then closed, and the remaining half of the water in the descending lock is run into the lower canal. The next descending vessel has to be floated into the lock which remains half filled, and which consequently requires only half a lock of water to be run from the upper pond to raise it to the proper level, and then that half is transferred to the lock previously

used, to serve the next descending vessel; but supposing a vessel to be ascending after the first descent, it will enter the empty lock, and receive a quarter lock of water from that which remained half filled: of course three-quarters of a lock of water is now required from the upper canal to complete the filling. If a descending vessel next follows, it enters the full lock, and its water is run into the lock which was previously left a quarter full, and when both have arrived at the same level, it is evident they will be each five-eighths full; and the succeeding descending vessel will require only three-eighths of a lock of water from the upper pond or canal.

From these observations it will be seen that the double transit lock saves nearly one-half the water which a common single lock would require.

Sometimes the two parallel locks are made of different sizes, to suit the various descriptions of vessels that may have to pass.

8th. Locks connected longitudinally, commonly called a chain of Locks.

When loss of water is of no consequence, a considerable expense is sometimes saved, by placing the locks close together without any intermediate pond, for by passing from one immediately into the other, there is only required one pair of gates more than the number of locks so connected, besides a proportionate saving of masonry. Thus, eight connected locks would only require nine pair of gates, whilst, if they were detached, they would require sixteen pair; but to show that these cannot be adopted with propriety, excepting when water is abundant, it is necessary to observe that every two alternate ascending and descending vessels will require as many locks full of water as there are locks; for instance, if a vessel has just ascended, it has left all the locks full, a descending vessel then enters the upper lock, and when its gates are closed, the water is run down, but all the locks below being previously filled, they cannot contain it, and it consequently passes over the gates or weirs of all of them into the lower canal: the vessel has by this means descended to the level of the second lock, the water in which must also be run into the lower canal, for the same reason as already stated. When the water of all the locks has thus been run down, an ascending vessel will require all these locks to be filled from the upper canal, which, however, will be retained in the locks ready for the succeeding vessel to pass down. From this it will be evident that where eight locks are connected, a descending vessel draws no water from the upper canal, because the locks are previously all filled, but it empties eight locks of water into the lower canal; an ascending vessel on the contrary empties no water into the lower canal, because all the locks were previously emptied, but it draws eight locks full from the upper canal in order to fill them; consequently the passing of one ascending and one descending vessel requires eight locks full of water.

9th. Other modes for passing vessels from one level to another,

By substituting machinery, either wholly or in part, have been adopted; but these have either failed entirely or not been brought into general use.

Trans. Institute Civil Engineers, vol. I.

Important experiments with canal boats at high velocities.

We extract from the *Edinburg Advertiser* the annexed account of some experiments, which prove that high velocities are attainable by properly constructed vessels, upon canals, or narrow waters, without raising a great wave, and consequently injuring the banks:—

"We regard the experiments described below as extremely important. If the result is correctly stated, and if no counteracting disadvantage has escaped notice, we think these experiments may be said to have added a million sterling to the value of canal property in Great Britain, since they must, at no distant period, add fifty or a hundred thousand pounds to the annual dividends. Nothing can be more paradoxical or startling in appearance than this result; and yet our knowledge of the many unexpected truths in mechanical science which experiment has brought to light, will not permit us to reject it as incredible. It is this:—*that the surge generated in a canal by the motion of a boat, and which is so destructive to the banks, in moderately rapid motion* (such as four or five miles an hour,) *ceases altogether when a high velocity is employed.* It is true the vessels were of a particular construction, but this is immaterial. A boat sixty feet long and five feet wide, is capable of being extremely serviceable, both for the conveyance of goods and passengers; and if a boat can be safely and conveniently dragged at the rate of nine or ten miles an hour upon our canals, passengers by this species of conveyance will then be upon a level, as to speed, with those who travel per mail. The great recommendations of canal carriage at present are, its cheapness, and the liberty of locomotion which passengers enjoy. Its leading disadvantage is its slowness; and this is now felt more and more, when our stage coaches are touching a speed of ten miles an hour, which will soon be doubled on our railways. We have not technical skill enough to know what a gig-boat is; but we infer from the other particulars stated, that it must be flat-bottomed in the cross section, pretty well curved upwards at stem and stern, and very light. With this form, the quicker it is moved, the less water it will draw. At a very high velocity, it will merely skim the water as it were; the displacement of the fluid will reach only a few inches down; and this circumstance, with the quick motion of the boat, causing a re-adjustment of the equilibrium of the water equally rapid, the necessary time will be wanting for the motion to propagate itself beyond the narrow zone of water which immediately encompasses the boat. Such is our hypothesis, supposing the fact to be as stated. We have a strong impression, however, that the result depends chiefly on the form of the boat, and that a much greater depth than five feet will be no material disadvantage, except where the canal is extremely narrow.

"Some months ago, by the suggestion of Mr. William Houston, of Johnstone, the committee of management of the Ardrossan and Paisley canal were induced to make certain experiments for ascertaining the rate of velocity at which a light gig-boat might be propelled along that canal. The experiments were made with a gig-rowing boat of about thirty feet in length, constructed by Mr. Hunter, boat-builder, Brown street, Glasgow; and this boat, with ten men on board, was drawn along the Ardrossan and Paisley canal, in the space of less than ten minutes, without raising any surge or commotion on the water—the force employed being one horse, rode by a canal driver. No account of this trial has ever been given to the public, but it was so satisfactory as to induce the committee of the Ardrossan canal to contract with Mr. Wood, of Port-Glasgow, for a gig-shaped passage-boat, sixty feet in length, and five in breadth, fitted to carry from thirty-six to forty passengers. In the month of April last, a number of experiments were made in the Forth and Clyde canal with two gig-boats fixed together, constructed by Mr. Hunter, and thus forming what is called a twin-boat. The object of these trials was to ascertain the rate of speed

at which vessels might be propelled along that canal, and the effect of a light double, or twin, boat, in giving that degree of steadiness which it was apprehended would be so much wanting in a light single boat. A statement of these experiments on the Forth and Clyde canal has already appeared in the newspapers, and the only fact therein mentioned, which it seems necessary to repeat here, is the remarkable circumstance, that the quicker the boats were propelled through the water, the less appearance there was of surge or waves on the sides of the canal. The result of the experiments was so satisfactory, that a twin-boat of a gig shape, sixty feet in length, and nine feet broad, was built by Mr. Hunter, Brown-street, Glasgow, and launched in the Forth and Clyde canal in the course of the following month.

"The single gig-shaped passage-boat contracted for by the Ardrossan canal committee, was launched at Port-Glasgow, on Wednesday, the 2nd of June, and she was towed up to the Broomilaw, and thence carried to Port-Eglington the day following; and on Friday, the 4th of June, a trial, of which the following is an account, took place. The boat is sixty feet long, four feet six inches breadth of beam, and drew on an average, including a deep keel, ten inches when light:—

"From the great hurry in which this trial was made, it was done under many disadvantages. The boat started from Port-Eglington for Paisley a few minutes after one o'clock, with twenty persons on board, and the distance from Port-Eglington to Paisley being seven miles, was accomplished in one hour and seven minutes. The rider was ordered to start and proceed the first mile or so at a very moderate pace, but even at this moderate pace the wave raised in front of the boat was very considerable. A high wave was seen on the canal preceding the boat, about eighty or ninety feet in front, and in some cases farther, and causing an overflow at the bridges and in the narrow parts of the canal. The surge or the cutting wave behind the boat was, however, comparatively slight, and, except the curves, would not have caused much injury to the canal banks. The horse was very much exhausted when he got to Paisley, though by no means so exhausted as he was about the middle of the journey, having sensibly recovered after the first four or five miles.

"Two post horses were hired there; and lighter towing lines being attached to the boat, it started again, on its return to Glasgow, with twenty-four persons on board, four of whom were boys, and arrived at Glasgow, a distance of seven miles, in forty-five minutes. The greatest speed attained during the journey, was two miles in eleven minutes. During this voyage the surge behind was entirely got quit of, even at the curves, where it was reduced to nothing; and there was no front wave except at the bridges. It appeared only at the bridges, and just as the boat was about to enter under the bridge, and disappeared as the stern of the boat cleared the bridge. *The quicker the boat went the more entire was the disappearance of all wave and surge*, except where the water escaped in the centre of the canal, and met in two very noisy and rapid currents from each side of the boat at the rudder. This noise and rush of water was so great behind as to induce persons on board to look round expecting to see a great wave or surge on the banks of the canal, but on the banks there was hardly a ripple. The two rapid noisy currents seemed to be completely spent and exhausted by the shock of their concourse behind the boat. Here, therefore, there was no room to doubt the correctness of the reports of the Forth and Clyde canal experiments. It was not merely to be said, that the greater the speed the less

surge or wave, but it was demonstrated, that, *at a high rate of speed surge and wave were done away with altogether.* Unluckily, there was no dynamometer attached to the rope, so as to ascertain whether, contrary to all theory, the strain or pull was not, equally with the wave, and the tugging labour of the two horses, lessened instead of increased, by the accelerated rate at which they drew the boat. There can be no doubt, however, that with one trained horse, properly attached, the distance could be done in a period under forty minutes. Contrary to expectation, Mr. Wood's boat was quite steady in the water, and by no means crank. It may be proper to mention that the Ardrossan canal is throughout very narrow; at the bridges, and many other places it is only nine feet broad. It has a great number of turns, and many of them very sudden." Mining Journal.

Mining product in England and Ireland.

Upon reference to the table in our last Number, it will be seen that the produce of six Mines alone in the county of Cornwall produced ores to the amount of 457,095*l.* 16s.; while one of them has given 25,295*l.* 5s. over the sum yielded by the returns of the preceding year. The Mines to which we allude as having given such increase are those of "Carn Brea;" and perhaps no better instance is afforded of the necessity of fairly examining the evidence on which Mines are resumed, involving, as in this case, an outlay of some fourteen or fifteen thousand pounds, and also of the success attendant on perseverance and the application of talent when directed to Mining operations.

The report on which the resumption of these Mines was founded, we have no hesitation in saying, was fallacious from beginning to end; lodes described as productive, hardly being in existence, while riches have been discovered that were not only unknown to, but unthought of by, the "ancients."

This, then, affords strong evidence, that much depends on the caution and perseverance adopted in working a mine; while the "Consolidated Mines," and that of "Tresavean;" may be selected as other instances of the advantages derived by the adventurer from carefully pursuing his object; the produce of the former amounting, during the past twelve months, to 139,963*l.* 1s.; and that of the latter to 88,358*l.* 3s. 6d. These Mines are worked to an extent beyond that of any others in the county, giving employment to thousands; and which, but for the perseverance and energy of a few, might have remained neglected to the present moment, as well as the "Carn Brea Mines," once in the possession of the "Cornwall and Devonshire Mining Company," which had also been unnoticed for years, until taken up by the present adventurers. Not however, to confine our observations to Cornwall, if we look to Ireland we find that one mine, the "Allihies," produced, in the twelve months ending the 30th June, ores to the amount of 79,181*l.* 7s. 6d.; while three others yielded 49,887*l.* 13s. 6d.; of which the "Knockmahon" Mines alone produced 25,743*l.* 3s. In these, however, are not included several which have been lately discovered, and among which we may instance the "Clare Mines," as being worked successfully under the able and efficient management of John Taylor, Esq; on whom the direction of the "Consolidated Mines," and others of equal importance, if not of equal magnitude, devolves.

These Mines, if we mistake not, were opened within the past two years by a few adventurers; the concern being now divided into about 130 Shares,

and a sum certainly not exceeding Two Hundred Pounds advanced to carry on the undertaking; from this trifling outlay Six Thousand Pounds have been already divided among the adventurers, and the value of the property may be estimated at the present moment at 35 to 40,000*l.* Here, then, we find that it is not necessary to travel far in search of riches,—our own country possesses them to an extent which would appear incredible, if not borne out by incontestible evidence; and when it is considered that the Mines of Cornwall produced, during the last year, ores to the amount of nearly ONE MILLION, we trust it is hardly necessary for us to impress on our readers the importance of mining operations, or to guard them from too hastily arriving at conclusions, or abandoning undertakings in which they may have embarked, either on account of their not yielding riches so soon as they contemplated, or because the state of the market is such as to confound the good and the bad together. Ibid.

A New Construction of Railways.

Mr. Perkins has just exhibited a new plan of railways, which he has secured by patent, and which from the explanation given by him, would appear calculated to supply the desideratum so long desired, and indeed appears to form an era in the progress of those great national undertakings towards perfection. The plan embraces two modes of construction, founded on one common principle, viz. the continuous support of the rails. In the one case this is effected by blocks of vitrified earth, as hard and durable as granite, and which lock into one another, being laid on a concrete foundation: and in the other, by an additional depth of concrete supplying the place of sleepers altogether. Upon the former plan, wooden bearers, four inches in the base, four thick, and two wide, on the top, rest upon the vitrified blocks; and in the latter, upon the concrete, to which they are firmly secured. In both cases, iron bars, with the means afforded for expansion and contraction, are fixed on the wooden beams, and the foundation being continuous and solid, in fact like one block of granite the whole length of the road, no vibration is felt, as the numerous persons who rode in the wagon unanimously testified; and this is an important attainment in railway constructions. The saving by the plan first described will, it is stated, be full £4000 per mile, in four rows; and by the latter, very much more—in fact, so enormous will it be, as to give a new feature to railways, and astonishingly facilitate their construction in all parts of the country. We should much like to see it in practice, which is alone the test: so fallacious are frequently found to be the results when based alone on novelty and experiments. Ibid.

Water Tanks.

At the late meeting of the Cornwall Polytechnic Society, a description was given of nine tanks, which had proved eminently useful during the late three dry summers on the Sussex property of Davies Gilbert, Esq., the President of the Society. As these tanks are cheaply and easily constructed, and not liable to decay like wooden vessels, and as rain enough falls on every house in England for the use of its inhabitants, no family would be deficient in good soft water who made a tank to *retain* it: and such tanks being paved over, take up no room.

The tanks of East Bourn vary in size: one of less than seven feet deep and

wide has served two labourers' families for three years; whilst most of the springs in the neighbourhood were dry.

A tank 12 feet by 7 had supplied with water a large family and six horses. This was surrounded by only 4½ inches brick-work resting solid against the sides, in consequence of being smaller at the bottom than higher up; and the dome is constructed on the Egyptian plan, by projecting horizontally each row of materials one-third of their length beyond those below, and filling up the back with earth as it proceeded, to balance the weight of this projecting masonry.

At the East Bourn Workhouse for fourteen parishes, a tank has been made 23 feet deep by 11 wide, of the roughest materials, being only flint stones, and though they require more mortar than if they had been regularly shaped, only 90 bushels of lime were allowed, including two coats of plaster, and the workmanship is executed like field walls at 10s. per 100 square feet; the only essential, being, that *no* clay be used (which worms bore *through*,) and that the lime or Parker's cement be good.

A current of air is said to promote the purity of water in tanks, and this is easily effected by the earthenware or other pipe which conveys the rain from the roof, being six or eight inches in diameter, and an opening left for the surplus water to run away; and where the prevailing winds do not blow soot and leaves *on* the house, the water remains good, even for drinking, without clearing out the rubbish more than once a year; but in some cases filtering by ascension may be found useful, and be effected by the water being delivered by the pipe at the bottom of a cask or other vessel from which it cannot escape till it has risen through the holes in a board covered with pebbles, sand, or powdered charcoal.

Upwards of twenty labourers' gardens have been watered by the rain which formerly injured the public road, and was therefore turned into a sink well, which sink well was enlarged and surrounded by nine inch masonry, and the water is drawn up by a *cast-iron curb*. This water was used in planting potatoes, and occasioned good crops in 1835, when sets not watered failed. And, should the profitable mode of *stall-feeding* now practised at Armagh be happily extended to England, and fatting oxen be kept *in pairs not tied up under shelter*, it will be found that preserving in tanks the water which falls on the barns and stalls will amply supply them, whilst it prevents the rain washing away the strength of the manure when straw is spread in the open yard.

Ponds have been made with equal success, dug only 4½ feet below the surface, what is excavated being added to the sides, and covered one foot thick like a road with pebbles and good lime mortar. Such ponds are become general on the dry soil of the South Downs for the use of the large flocks of sheep: and had such ponds been made in Romney Marsh, &c., during the late dry years, the sheep would not have died in such numbers as materially raised the price of meat in London.—*Bath and Cheltenham Gazette.*

On the Formation of Mineral Veins. By R. W. Fox, Esq.

Mr. Fox is of opinion that mineral veins were originally fissures probably caused by changes in the earth's temperature; that they were small at first and gradually increased in their dimensions; and that the mineral contents progressively accumulated during the whole period of the development of the fissures; and as changes in the earth's temperature might produce changes in the direction and intensity of the terrestrial magnetic curves, he

conceives that electricity may have powerfully influenced the existing arrangement of the contents of these fissures.

Copper, tin, iron, and zinc, in combination with sulphuric and muriatic acids, being very soluble in water, Mr. Fox says, they would in this state be capable of conducting voltaic electricity; and as the rocks forming the walls of the veins contain different salts, they would be in opposite electrical conditions, and hence currents would be generated and readily transmitted through the fissures, and in time the metals would be separated from their solvents and deposited in the veins. But on the known principles of electro-magnetism, Mr. Fox adds, it is evident that such currents would be more or less influenced by the magnetism of the earth; and therefore that they would not pass from north to south or from south to north as easily as from east to west, but more so than from west to east.

The author then offers some observations relative to the production of sulphurets from the decomposition of the metallic sulphates; and explains how fissures, gradually widening, would be successively filled, and would account for veins occurring within veins; he offers some remarks also on the greater productiveness exhibited at the points where veins pass from one formation to another, and is of opinion that the fact may be explained by supposing the rock in which the vein is productive to have been electro-negative.

In conclusion Mr. Fox states, that if in other parts of the world veins may be found to deviate from an east and west direction much more than they do in England, the apparent discrepancy may be explained by the rocks having yielded more easily in one direction than in another, and from a difference in the direction of the magnetic meridian in different countries, as well as from the probability that it has varied greatly at different epochs.

L. & E. Phil. Mag.

Progress of Physical Science.

On the Effects of a Battery charged with Sulphate of Copper. By W. De La Rue.

Having witnessed in our own experiments, doubtless in common with most lecturers in this country, the energetic effects of Sulphate of Copper as the exciting fluid in the voltaic battery, we would suggest the further trial of it in conformity to the experiments of De La Rue in order to determine how far it may be preferable to the acid solutions commonly employed. Its enduring and even increased action after the lapse of two hours may give it no trivial advantage on certain occasions. G.

The greatest effect being always produced in those voltaic arrangements where the chemical agent exerts an action on only one of the metals constituting the battery, it occurred to me to use a saturated and perfectly neutral solution of the electro-negative metal, provided the other was capable of effecting its decomposition. I therefore tried the effect of a saturated solution of sulphate of copper in an elementary voltaic battery of the ordinary construction. The zinc plate was four inches by two, the copper completely surrounded it: with this I was enabled to produce ignition of half an inch of platina wire one thirtieth of an inch in diameter, and continue it as long as the zinc plate lasted, which, being very thin, was dissolved in a couple of hours. The effects of this battery were considerably greater

than those of one made of platina and zinc of the same dimensions, this being immersed in diluted nitric acid.

I afterwards constructed a battery with three four-inch zinc plates connected together; these were immersed in a copper trough with two partitions, so that the zinc should be opposed on both its surfaces to a plate of copper: with this battery one inch of fine iron wire was kept ignited for four hours. The zinc plate is always partially covered with a coating of copper, *which, however, is* NOT DETRIMENTAL *to the power of the battery:* the copper plate is also covered with a coating of metallic copper, which is continually being deposited; and so perfect is the sheet of copper thus formed, that, on being stripped off, it has the polish and even a counterpart of every scratch of the plate on which it is deposited. Besides this, the voltaic influence decomposes the water; the oxygen, uniting with a portion of the copper and hydrogen being set at liberty. This may be readily shown by soldering at one end a piece of copper and a piece of zinc, coiling the two to form a small calorimotor, which is to be put into a glass jar filled with a solution of sulphate of copper, and inverted in a vessel of the same; metallic copper and its oxide will precipitate, and hydrogen gas fill the jar.

Seeing the effects so continuous in a simple battery, I tried a Cruickshank's, of one hundred pairs, each plate exposing to the action of the fluid a surface of twenty-five square inches. This was charged with a saturated *cold* solution of sulphate of copper, to each three gallons of which I added two ounce measures of nitric acid, for the purpose of cleaning the plates and freeing them from oxide; for half an hour the action was so feeble that I was on the point of emptying the trough, but I soon after noticed that the effect was rapidly increasing; I was then induced to proceed. The batteries attained their maximum of power in three quarters of an hour after charging.

Charcoal points were vividly and continuously ignited, the arc passing through a space of three-eighths of an inch; this experiment was beautifully varied by dipping the charcoal in nitrate of strontian, the arc then being of a crimson colour.

Steel points of wire, a quarter of an inch thick, were then tried; the arc passed through on equal space; the steel rapidly fused, was deflagrated, and by the scintillations produced a beautiful effect.

Copper points treated in a like manner produced a green arc, and were rapidly destroyed.

Brass produced a blueish white arc; and the more fusible metals, such as bismuth and tin, produced likewise an arc, but the metal was soon carried from one point to the other and established a perfect contact.

A piece of platina wire, one eighth of an inch thick, was rapidly fused, by keeping it at a short distance from a disc of copper, so as to allow the arc to pass from it to the disc.

A *heap* of metallic leaves was burned with rapidity.

Thick tin-foil was deflagrated.

Very thick zinc-foil was rapidly consumed. A bunch of needles burned rapidly in mercury; the end of a file was deflagrated in the same manner.

Extraordinary as was the power of deflagrating metals, the effect of igniting was comparatively small; not more than an inch of iron wire could be ignited, though, if only twelve pairs of Wollaston's four-inch plates were used, charged with the same solution, two and a half inches could be kept ignited for some time.

The battery was then tried in decomposing common caustic potash, which it did with facility; the combustion of the potassium evolved, vividly igniting the thick platinum wire used for the negative pole. These experiments occupied about two hours. The charcoal points were then again tried; and if there were any alteration the power of the battery had increased. Batteries charged in this manner will continue in unabated action for upwards of three hours; in fact until there no longer remains any copper in the solution. It is worthy of notice, that after the batteries have been in action some time, a large portion of the sulphate of copper is expended, and replaced by sulphate of zinc, *yet the action continues the same.* This naturally suggests using a saturated solution of any neutral salt, common salt for example, and adding merely as much of the solution of copper as will serve for the time required. It is not unlikely that the effect would be more continuous than with a solution of copper only. I intend trying this, as I am still pursuing my inquiries on this subject, the object of which is to simplify as much as possible the voltaic battery.

At the Marylebone Institution, on Monday, September 12, when a lecture was delivered on this subject by Mr. Hemming, the President, the power used was the hundred pairs of Cruickshank's arrangement before alluded to, and one hundred and thirty-two pairs of Wollaston's four-inch plates, making in all two hundred and thirty-two pairs.

The batteries I charged *before* the commencement of the lecture, and they were not used till an hour afterwards; the effects were very striking. The arc from the charcoal points pass through a space of three-quarters of an inch, and the effect continued unabated for as long a time as could be spared for this experiment; soda was rapidly decomposed, and the sodium brilliantly deflagrated: all the other experiments before cited were repeated on a much grander scale. The lecture being concluded two hours and a quarter after charging the batteries, the charcoal points were again ignited to light up the spacious theatre, the gas having been extinguished. The shock was very powerful, even when taken in the hands dry.

Fifty pairs of four-inch plates on Cruickshank's plan suffice for all the above experiments, except the decomposition of the fixed alkalies.

Water was decomposed with extraordinary rapidity by a battery of this description, and also muriatic acid, the chlorine of which bleached a solution of sulphate of indigo in a few seconds.

Its effects on the animal system, as exhibited by Mr Hemming to the audience, were almost terrific. A rabbit recently killed, an eel, and frogs were thrown into more violent muscular action than I had ever previously witnessed.

The *tension* of electricity seems to be greatly increased by this mode of charging the voltaic battery. Ibid.

Changes of Magnetic power and capacity by Temperature.

Dr. Faraday has shown that iron loses all magnetic property at an Orange heat, and is then, to a magnet, just like a piece of copper, silver or any other unmagnetic metal. It does not intercept the magnetic influence between a magnet and a piece of cold iron or a needle. The point at which iron loses and gains its magnetic force appears to be very definite, for the power comes on suddenly and fully in small masses by a small diminution of temperature; and as suddenly disappears upon a small elevation at that degree.

The point at which nickel loses its magnetic relations is very much lower than with iron, but equally defined and distinct. Almond oil can communicate that temperature which can render nickel indifferent to a magnet. This appeared to be at about 630° or 640° F. A slight change about this point would either give or take away the full magnetic power of the metal.

It was not found that the conducting power of these metals for electricity, was effected by the sudden changes of temperature that destroyed or conferred this magnetic virtue.

To determine whether such a reduction of temperature as might be artificially produced, would confer magnetism in other metals—the following, viz:—

Arsenic,	Lead,
Antimony,	Mercury,
Bismuth,	Palladium,
Cadmium,	Platinum,
Cobalt,	Silver,
Chromium,	Tin,
Copper,	Zinc,
Gold,	

were reduced to a temperature of from 60° to 70° Far. below zero by means of the evaporation of sulphurous acid. In this state they were brought close to one end of one of the needles of a delicate astatic arrangement, but in no case was there the least indication of magnetism.

This range of temperature is, however, so limited compared with that at which iron and even nickel lose their magnetism, it does not, in the opinion of Dr. Faraday, disprove the probability that all the metals may acquire magnetic powers at certain low temperatures, or to prove the idea that iron and nickel, with regard to magnetism, are to be considered as exceptions from the metals generally, any more than mercury can be considered as an exception as to liquefaction.—*Abstract Lon. & Ed. Phil. Jour.*

On Lightning. By M. Arago.

M. Fusinieri has been lately studying the effects of Lightning under an entirely new point of view.

According to this *physicien*, the electrical sparks issuing from ordinary machines, which we see as they traverse the air, contain brass in a state of fusion, and incandescent molecules of zinc, when they emanate from a brass conductor; if the sparks issue from a ball of silver they contain impalpable particles of that metal. In the same way, a globe of gold gives rise to sparks, which contain, during their passage through the air, melted gold, &c. &c.

The molecules in the centre only of all these sparks are melted; on their exterior surfaces the metallic particles undergo a greater or less degree of combustion, in consequence of their contact with the oxygen of the atmosphere.

When a spark issuing from a globe of gold passes through a silver plate, even of considerable thickness, there is seen on the two surfaces of the plate, at the points where the electric spark entered and emerged, a circular stratum of gold, the thickness of which must be very inconsiderable, since, if left to itself, it volatilizes, and disappears entirely in a short time. According to M. Fusinieri, these two metallic spots are formed by the fused

gold which the electric spark contained. The deposit on the first face is nothing extraordinary; but, by adopting the explanation of the Italian *physicien* for the spot on the opposite surface, we are obliged to admit, that the gold disseminated through the spark has passed, at least in part, along with it through the whole thickness of the silver plate! It is unnecessary to add, that a spark issuing from a ball of copper gives rise to similar phenomena.

A spark emanating from one metal, and passing through another, does not only lose a portion of the molecules with which it was at first charged, but it acquires new molecules at the expense of the metal traversed. M. Fusinieri even asserts, that, at each passage of the spark, reciprocal changes are produced between the two metals present; that when the spark, for example, leaves silver to pass to copper, it not only transports a portion of the first metal to the second, but that it likewise transports copper to the silver! I will insist no longer, however, on these phenomena; I have cited them here only with a view to show that the sparks of our ordinary machines contain ponderable matter.

M. Fusinieri affirms that similar matter exists in lightning, and that in this case also it is in states of minute division, of ignition, and of combustion. According to him, this transported matter is the true cause of the transient smells which thunder occasions when it falls, and also of the pulverulent deposits which remain round fractures through which the electrical matter has forced a passage. In these deposits, which have been too much neglected hitherto by observers, M. Fusinieri has detected metallic iron, iron in different degrees of oxidation, and sulphur. The ferruginous spots left on the walls of houses may be found, when strictly examined, to arise from the iron with which the lightning was charged, derived from that which occurs in every building; but what is to be said regarding the sulphurous spots on these same walls, and especially the ferruginous marks which are found on trees struck with lightning in the open fields? M. Fusinieri conceives himself authorized to infer from these experiments, that the atmosphere contains, at every height, or at least as far as the region of stormy clouds, iron, sulphur, and other substances, on the nature of which chemical analysis has been hitherto silent; that the electrical spark is charged with them and that it carries them to the surface of the earth, where they form attenuated deposits round the points struck with the lightning.

This new method of regarding electrical phenomena, assuredly deserves to be followed up with that accuracy which is suited to the present state of science. Every one who witnesses a stroke of lightning, would perform a very useful service by carefully collecting the black or coloured matter which the electrical fluid seems to deposit, at all those stages of its progress where it undergoes sudden changes of velocity. A careful chemical analysis of these deposits may lead to unexpected discoveries of high importance.

Mag. Pop. Science.

Rain in a perfectly Clear Sky. By M. Arago.

There are some extraordinary phenomena, concerning which science possesses but few observations; and for the reason, that those who have had the opportunity of witnessing them avoid describing them, from an apprehension that they might be regarded as undiscerning visionaries. In the number of these phenomena we may rank certain rains of the equinoctial regions.

Sometimes *it rains* between the tropics when the atmosphere is perfectly

pure, and the sky of the most beautiful azure! The drops are not very numerous, but they are larger than the greatest rain-drops in our climates. The fact is certain; we have the evidence of M. von Humbolt that he has observed the occurrence in the interior of continents, and Captain Beechey states that he has witnessed it in the open sea. With regard to the circumstances on which such a singular precipitation of water depends we are entirely ignorant. In Europe we sometimes see during the day, in cold and perfectly clear weather, small crystals of ice falling slowly from the air, their size increasing with every particle of humidity they congeal in their passage. Does not this approximation put us in the way of obtaining the desired explanation? Have not the large rain-drops been at first, in the higher regions of the atmosphere, small particles of ice excessively cold; then have they not become, as they descended, large ice-flakes by means of accumulation; and when lower still, have they not melted into drops of water? It will be readily understood that the only object with which these conjectures are brought forward in this place is, to show in what point of view the phenomenon may be studied, and to stimulate our young travellers, in particular, to observe carefully if, during these singular rains, the region of the sky from which they fall presents any traces of halo. If such traces are perceived, however slight they may be, the existence of crystals of ice in the higher regions of the air would be demonstrated.

In the present day there is scarcely any country where meteorologists are not to be found, but it must be confessed that their observations are usually made at hours selected without proper discernment, and with instruments either inaccurate in themselves, or improperly placed. It does not now appear difficult to deduce the mean temperature of the day from observations made at any hour; thus a meteorological table, whatever may be the hours of observation in it, may be possessed of value, by the mere condition that the instruments employed will admit of comparison with a standard barometer and thermometer. Ibid.

On the Time of Rotation of Jupiter. By F. G. Airy, Esq., *Astronomer Royal.*

Kepler inferred, from a presumed connexion between the time of the rotation and that of its first satellite, that Jupiter's time of rotation was less than 24 hours. Cassina was led from his own observations in 1664–5 to conclude that it was less than 14 hours. Subsequent observations in 1665 led him to the time of 9h 56m 0s. This is the period adopted by Laplace, and all subsequent writers.

In December, 1834, Professor Airy took advantage of one of the two remarkably black and well defined spots which appeared near the lower belt of the planet, to make a series of observations, with a view to the determination of the period of Jupiter's rotation with greater accuracy. These observations extend over the period from December 16th to March 19th following: and from them, by methods which he details, he finds that the true period corresponding to them is 9h 55m 21.3s, mean solar time.

This close approach (differing only 38.7 seconds) to the period determined by Cassini, will seem remarkable enough to those who estimate by numerical differences the degree of approximation, without considering the unit by which those differences are measured: but to those who are accustomed to look upon an inquiry in all its details, and under careful mathe-

matical discipline, it is obvious that this small quantity may be in reality a comparatively great one. It is so in the present case.

The time of the visibility is less than five hours; and the period of observation extending over 225 revolutions, from which Mr. Airy deduced his period, it would make 225 × 38.7 seconds, or 2h 25m 0.75s, or about half the period of the visibility of the spot itself. The period then assigned by Cassini is, as the author remarks, incompatible with the observations recorded and discussed in his communication. Ibid.

Artificial Production of Metallic Sulphurets, &c.

The Geological Section of the "British Association for the Advancement of Science," having received as novelties some communications on this subject, we think it due to M. Becquerel to state, that he obtained by this means a very considerable number of substances, above seven years since. His apparatus consisted of a tube bent into a syphon shape U, the curved portion being filled with moistened clay, (argile bumectèe,) and the legs with solutions of the substances of which combinations were sought, and connected by a wire. The *crystalline metallic* bodies which he obtained were,

Metallic copper.
Red oxide of copper.
Vitreous copper.
Grey copper (fahlertz.)
Metallic silver.
Vitreous silver.
Chloride of silver.
Sulphuret of lead.
Carbonate of lead.
Sulphate of lead.
Oxy-sulphuret of antimony (kermes.)

Besides a considerable number of alkaline sulphurets, chlorides, bromides, and many double sulphurets, salts, &c.

Full details will be found in M. Becquerel's work "de l'Electricite et du Magnetisme, Tome i., 332–350." Rec. Gen. Sc.

Analysis of Tobacco. By. Berthier.

Equal weights of several different varieties of Tobacco, having been carefully dried and weighed by the Deputy Inspector, at the Royal Tobacco Factory, each portion was converted into ashes, and then put into the hands of *M. Berthier* for examination. The ashes were all perfectly white and contained neither iron nor manganese.

The relative quantities of soluble matters in the several roots were: Havana .382; Virginia .502; Maryland .600; Alsace .313; North of France .370; South of France .265.

Of alcaline salts in the different ashes the following were the proportions.

	Havana.	Virginia.	Maryland	N. France	S. France	Alsace.
Carbonate of potash,	.610	.845	.860	.450	.000	.455
Sulphuret of potash,	.200	.047	.044	.181	.308	.455
Chloride of potassium,	.190	.108	.096	.369	.692	.090
	1.000	1.000	1.000	1.000	1.000	1.000

It thus appears that the American specimens are much richer in alcaline carbonates than those of Europe. It is very remarkable that the tobacco of the South of France (Departement des Lot) contains none at all.

Of Lime, Magnesia, Silica, Phosphate of Lime and Carbonic Acid they all contained portions not very materially varying from each other. It is thus proved that plants of the same species have the property of extracting from very different soils, the mineral substances adapted to their own nature, and rejecting others. Ann. des Mines.

Mechanics' Register.

New Lamp.

A lamp of a new construction, which describes a circle of light of about thirty feet in diameter, of the apparent intensity of sunshine, showing the objects within its sphere as distinctly as on the table of a camera obscura, has been erected at the head of the inclined plane in St. Leonard's depot. Its object is to enable the engine-man to have a distinct view of the inclined ropes during the night, and this has been fully attained. The lamp consists of an Argand burner, placed in the focus of a large speculum, of a peculiar form, by which the whole light is distributed just on the space where it is required. It is computed that the light on the above space is equal to that of twenty-five or thirty similar burners in common lamps. A lamp of this kind we have no doubt would be useful for other purposes. It appears to us that the largest assembly-room might be brilliantly lighted by one placed at each end of the room, and one would be sufficient to light the stage of a theatre. The cost of this one is said to be about £200, but we understand it saves an annual expense of about half that sum. The inventor is a Mr. Rankin, and he names it the conoidal lamp, probably because the light is thrown from it in the form of a cone.—*Caledonian Mercury.*

Extraordinary Draught by one Horse.

The following extraordinary feat of a draft horse has been recorded. Soon after the completion of the Surrey Iron Railway, and when it was open for the conveyance of goods from Wandsworth to Mertsham, a bet was made, that a common horse could draw thirty-six tons for six miles along this road, and that he should commence his labour with a dead pull, as well as turn it round the occasional windings of the road. A number of persons assembled near Mertsham to witness the performance. Twelve wagons loaded with stones, each wagon weighing three tons, were linked together, and a horse, taken from the timber team of Mr. Harwood, was hooked to the first wagon. He started from near the Fox public house, and drew this immense weight with apparent ease, to near the turnpike at Croydon, a distance of six miles, in one hour and forty-one minutes. In the course of his journey, he was stopped four times, in order to show that it was not by the acquired impetus that he performed the task. After each stoppage, a chain of four wagons was added to the train, with which the same horse set off again without difficulty, even after about fifty men had mounted them. Far. Mag.

Effects of Lightning.

M. Baric, of La Haye, has communicated to the French Academy of Sciences the remarkable growth of a poplar which had been struck by lightning. It grew in an avenue belonging to him. The lightning broke some of the branches at the top, and the fluid ran along the trunk, from the top to the bottom of the northern side, without injuring the bark, went into the ground at the root, and turned up two large masses, each nearly a cubic foot in size. The tree at that time measured twelve inches in circumference, and it was in the month of July that the circumstance occurred. In the following April the trunk had exactly doubled its size, while the trees close to it retained the same girth; and the sap flowed in such abundance as to force its way through the bark. Ibid.

Statistics of the Book Trade in Germany, France and England.

Germany still stands pre-eminent in the extent of its Book-trade. The annual value sold is estimated at £860,000 sterling; thirty years ago the trade was in the hands of only three hundred booksellers, or publishers. At present there are not less than 1094, including ninety-two commercial house of Switzerland, Hungary, Prussia and its Polish provinces. Through the Germanic Confederation there is one book-shop to 93,000 souls, while in Austria there is only one to 122,222. The progression, as regards intelligence, is still more striking in Prussia, where there is a book-shop to every 33,899 persons; in 1830, there were 200, which, in 1833, had increased to 293. At least fifty-eight new book-shops have been established in different parts of Germany between Easter, 1832, and Easter, 1833. The number of works published in that country has increased in the following proportion: (1827) 5000, (1828) 5,600, (1832, in which year many pamphles were published) 6,122, (1833) 4,635 (?) Of these, Austria furnished 290, Prussia 1058, Saxony 1810. Leipsic is the centre of this immense commerce.

If we compare the total number of works published in Germany from 1814 to 1820, which were 50,393, and the number published in France during the same period, which was only 16,528, it would not at first be imagined that the proportional increase of literary works has been much greater in the latter than the former country, but so it is; the aggregate amount of works was barely doubled in Germany, while in France in 1826, the number published was 4347, or four times as great as in 1814. In 1828, the French publications were 7616, a number never reached in the catalogue of the celebrated annual Leipsic fair. The fluctuations in the labours of the French press are to be attributed to political events. In 1811, forty-five millions, and in 1826, 144 millions of sheets were printed in France, the former number giving $1\frac{3}{5}$, the latter $4\frac{1}{5}$ sheets for each individual.

In England, including pamphlets, reprints, newspapers, magazines, &c., the value of printed works in 1833 amounted to £2,420,900. sterling.

This trade is almost entirely in the hands of the London booksellers, of whom there are 832, nearly as many as there are in Germany. The division of trade in this central mart of book-trading is remarkable; there are booksellers who entirely devote themselves to the sale of religious works, others to that of elementary works for instruction, and so on. Exclusive of pamphlets, reprints, and newspapers, the number of volumes published in England rose from 1105 in 1828, to 1507 in 1833, between which periods there was an annual increase of about ninety-two or ninety-three volumes, caused

by the rapid progress of "cheap literature," which has effected a reduction in the mean price per work from 12s. to 10s. 7d. Mag. Pop. Sci.

Great Central Heat of the Earth, not alarming.

"It appears, that if there be an increase of temperature in descending, such a fact can result from nothing but a central heat, independent of existing influences.

"The discussion of the evidence of this fact must be left to the geological speculator; but we may here mention some of the results of the theory, which are fitted to make less formidable the idea of having a vast abyss of incandescent matter, within the comparatively thin crust of earth on which man and his works are supported. It results from Fourier's Analysis*, that at 124 miles deep the earth may be actually incandescent, and yet that the effect of this fervid mass upon the temperature at the surface may be scarcely a perceptible fraction of a degree. The slowness with which any heating or cooling effect would take place through a solid crust, is much greater than might be supposed. If the earth, below 33 miles deep, were replaced by a globe of a temperature 500 times greater than that of boiling water, 200,000 years would be required to increase the temperature of the surface one degree†. A much smaller depth would make the effect on the superficial temperature insensible for 2000 years. It is calculated, moreover, that from the rate of increased temperature in descending, the quantity of central heat which escapes in a century, through a square metre (about 3 feet $2\frac{1}{4}$ inches by 3 feet $2\frac{3}{4}$ inches,) of the earth's surface, would melt a column of ice, having that metre for its base, and 3 metres (9 feet 8 inches) high."

Estimate of the Solar Heat imparted to the Earth.

It may be curious to contrast the effect of the heat ascending to the earth's surface, as above stated, with that annually poured down upon it by the sun. This is estimated by Pouillet‡ to be sufficient to melt a coat of ice, 14 metres thick, (about 46 Eng. feet,) incrusting the whole globe of the earth.—Whewell, *Report on Electricity, &c.; Dublin Session, British Association*, 1835.

Copper Smoke.

Attached to the New Copper Works, belonging to Messrs. Vigors and Co., in Cwm Avon, is a tunnel for consuming and conveying copper smoke, one thousand one hundred yards in length: viz. from the smelting furnaces to the top of the high hill towards the north west, called Môl-y-Mynydau. In this elevated spot the small quantity, if any, that will escape precipitation, will find its way into the air. Few persons probably are aware of the immense quantity of copper thus saved to the proprietor, which, in former times, was deposited on the neighbouring lands, subjecting him to most expensive actions. In a tunnel not long since made by Messrs. Williams & Co., in their works on the Swansea river, two hundred tons of copper were taken out, which had been precipitated in the short space of one year—the value of this was 2000*l.*, and much was still left in the tunnel. Chambers are made in the tunnel for attracting the smoke, which is further promoted by the use of steam, so that little of it is allowed to reach the place of exit, till it has deposited, *in transitu*, all its substance. This material, therefore, which not only was formerly lost, but did serious mischief to the adjoining

* *Bull des Sci.* 1820, p. 58. † *Mem. Inst.* Tom. vii. p. 603. ‡ Tom. ii. p. 704.

lands, thereby entailing lawsuits of ruinous expense, becomes now a matter of important profit.—*Merthyr Guardian.* Mining Journal.

Weaving in Glass.

Signor Olivi, of Venice, has recently succeeded in bringing to perfection a manufacture which may prove of great value, and may be applied to many purposes of usefulness and luxury. It is the art of weaving a tissue from threads made of glass. The process of which the Signor is the inventor differs from all the attempts of the same kind which have been previously made in other countries, as it is to take every degree of shade from the most perfect transparency to the deepest opaque. The thread is also rendered so perfectly flexible, as to allow itself to be tied, or the tissues when manufactured to be folded like silk. Another great advantage attending it is, that it resists the action of fire. The specimens which have been exhibited have called forth the highest admiration, and the brilliancy of colour given to them is altogether surprising. Although the Institution of Arts of Venice has awarded medals to Sig. Olivi for his invention, it is said that he does not meet with the encouragement from the Austrian Government which he expected its singularity and beauty would ensure; and a friend of his is consequently about to proceed to Paris, with a view to making it known in that city, where every thing relating to the arts is encouraged, in the hope that his efforts will there meet with a better reward, and that the invention itself may probably be brought to still greater perfection.

Ibid.

Extraordinary Effects of Concussion.

The Commissioners of Police have for two or three years past been opening a magnificent thoroughfare from the Exchange to the New-road, leading to Bury, Burnley, &c. To do this it was necessary to erect an immense stone wall on the edge banks of the river Irwell, and the average height of which was to be 50 feet. About 120 yards of this has been completed some time, and the workmen were proceeding with the remainder; the height of which unfinished wall varied from 40 feet to about 15 feet, and which was exactly opposite the works of Messrs. Collier and Co., extensive fustian-shearers and finishers, and wool-combing machine makers. About twenty-five minutes past eight this morning, then fortunately breakfast hour, or 50 men must at least have perished, this immense wall, 65 yards in length, and 7 thick, without warning, came tumbling down, and fell in one mass, broadside on, into the river Irwell, and the consequences are almost incredible, viz. the total destruction of the works on the opposite side of the river (which is 40 yards wide) belonging to Messrs. Collier and Co., attended with the loss of life, and of several wounded. The injury done to the buildings on the opposite side of the river may no doubt be philosophically accounted for, although not a brick nor a piece of stone that formed part of the wall could by any possibility have come in contact with them. Let it only be supposed, then, that a wall, 200 feet long and 7 feet thick, falling in one connected mass, broadside on, into the river, and some idea may be formed of the amazing concussion of the air, and the force with which such an immense mass of materials would force both it and the water against the opposite buildings, and the desolation produced may be accounted for. The roof was not only blown off, but the buildings literally blown down also, and of course, all the machinery destroyed.—*Manchester Times.*